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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

JANUARY 23.

Institution of Welding Engineers:—Ordinary meeting at Caxton Hall, Westminster, London, S.W.1. A. E. Plumstead will read a Paper on "Electric Welding Repairs to Inflated Gasholders."

JANUARY 27.

Institute of Metals (Sheffield Local Section):—Conjoint meeting at the University, Sheffield. "The Metal Aeroplane," Paper by J. C. Buchanan, O.B.E.

Institute of British Foundrymen.

JANUARY 21.

Lancashire Branch (Burnley Section):—Annual social at Burnley.

JANUARY 27.

Middlesbrough Branch:—Ordinary meeting at Middlesbrough. "Foundry Costing," Paper by D. G. Pennington.

Scottish Branch (Paisley Section):—Ordinary meeting. "Some Notes on Continental Foundry Practice," Paper by James G. Arnatt.

Industrial Co-operation.

It is interesting to note the various interpretations which are being placed upon the meeting which was held last week between a group of prominent employers and the council of the Trades Union Congress. One section is running away with the idea that the object is merely the preparation of an omnibus agreement to eliminate strikes, whereas our interpretation is the provision of conditions which eliminate the cause of strikes. Probably the major condition to which labour disputes are attributable is scarcity of remunerative orders, which engenders in the ill-informed operative an incentive to work slowly in order to eke out the work as long as possible, whilst the non-erudite employer can only see the cutting of wages as a means of earning a profit. "The Times," in a leading article dealing with the present unsatisfactory condition in the cotton textile industry, had the courage to support the operatives in the position they have assumed, as its writer considers some of the employers' proposals as being retrograde. The constructive part of the article coincided with Mr. E. Longden's proposals for the revival of the British foundry industry, recently disclosed to the Lancashire section of the Institute of British Foundrymen. These were founded on his personal survey of American conditions, and, it will be remembered, were based upon the rather elementary principle of cooking the pudding in the most suitable size of pot and under the best pudding-cooking conditions. Thus, we expect that, if and when a report is made, the primary condition to be postulated is that industry must be made prosperous if not opulent. Then we anticipate that in order to eliminate excessive domestic competition amalgamations or commercial arrangements will be recommended, so that the "best" factories (from a low-cost production point of view), will be filled to the maximum so that overheads will be at a minimum. If under these conditions no profit can be shown, then either the further mechanisation of the plant or the lowering of the standard of living, or the closing down of the industry must be envisaged. In the last case this would necessitate the transference of labour to some industry that can more easily compete in the world's markets. We are aware that such conditions would impose great hardships upon various sections of industry, but they are neither better nor worse than abortive strikes, lockouts or bankruptcy proceedings, which carry with them the partial or complete ruination of allied concerns and industries. Such are the conclusions we expect from the industrial conference, naturally accompanied by a series of clauses or recommendations ancillary to their exploitation.

Exchange Papers.

We have recently discussed at some length the question of papers on foundry subjects, with reference both to their nature and their number, but we have not as yet considered the important question of the Foreign Exchange Paper, a development of some few years ago, in its sponsorship of which we believe the Institute of British Foundrymen to be unique among technical societies in this country.

The value of such Papers is unquestioned, and may be roughly analysed under three heads. In the first place they afford a means of learning about and assessing developments abroad that is vitally important to those of us—and they are the great majority—whose knowledge of foreign languages is not sufficient to enable us to read of work going on abroad in the pages of the foreign technical Press. Within the differing limits of their respective spheres, this Journal on the one hand, and the Cast Iron Research Association on the other, endeavour to select and translate such Papers as seem to them to be of outstanding importance; but such a policy is very strictly limited by the cost of translation—a fact which is not sufficiently recognised.

Moreover, the foreign exchange Paper furnishes, in addition to its primary subject-matter, a background and perspective that cannot otherwise be obtained without detailed and intimate personal knowledge of the country of its origin. With the best will in the world, the external observer cannot be in so good a position as the native expert to assess the relative importance—in the country concerned—of this and that method, this and that development.

Thirdly, the foreign exchange Paper has the great merit, which it shares with all forms of international conference, discussion, etc., of establishing direct personal contact between the interested parties in the country whence the Paper comes and the interested parties in the country in which it is presented. No one who has any experience at all in the matter would venture to doubt the very real advantages that accrue from such contact.

Bearing these points in mind, it is not surprising that there is general agreement as to the types of Paper which have the greatest value for exchange purposes. The most valuable are found to be either general reviews of recent development, given preferably by a man himself responsible for some one item in this development, or an account by the responsible party of a single significant advance.

It is not, of course, for us to dictate to our foreign friends, but on the assumption that they might reasonably share these views we can make it our business to see that our own exchange Papers are of the type we ourselves find most useful.

The qualification for producing such a Paper would thus become record of previous contributions to the I.B.F. proceedings rather than ability to produce a novel Paper. The I.B.F. would be strengthened in its claim—which amounts almost to a moral right—to the first hearing of new work done by its members, while the difficulties both of principle and of practice that attends the first presentation of new work in a foreign tongue would thus be overcome.

XUM

Patternmaking.*

By A. C. Furmston.

The subject of patternmaking is not one to lend itself to sensational treatment. There cannot be any startling discoveries or developments in the patternshop, as good patternmaking consists rather of careful attention to details, all important but all obvious.

In actual practice a patternmaker is usually given a drawing, and from the information he can gather from it he has to make a pattern for use in the foundry. In other words, he has to translate the ideas of the draughtsman or designer as expressed in a drawing, into such form that it will enable the foundryman to make his mould with the minimum of trouble, and to produce accurate castings. Patternmaking is a part of the process of producing castings and is not an end in itself. However fine a piece of work a pattern may be it has no value except as a means of producing castings.

A patternmaker has to be expert in reading drawings; should have a very good idea of moulding practice; must be a good handicraftsman, skilled in the use of tools, whilst possessing a good knowledge of the materials in which he has to work; he has to understand the contractions of the various metals, and is expected to know enough of machine-shop practice to allow the correct amounts for machining and fitting.

Patternmaking must necessarily cover almost as wide a field as engineering itself, and the work varies considerably, few men have the opportunity of gaining experience in all classes of work, and the tendency is for men to keep in those lines with which they are more or less familiar. It is difficult to find a man who can adapt himself to widely different classes of work.

Materials Used.

Many different materials are used for making patterns, but the principal ones are wood, metal and plaster, but there is no perfect material. Wood, for instance, can never be definitely relied on to keep its shape, moreover, it is fairly easily damaged. Metal patterns are much more costly to make, and in many cases the weight would be prohibitive. The best material to use must depend on circumstances, primarily, especially the number of castings required and if the shape is fragile or otherwise.

If only one casting is wanted then the least expensive pattern is called for, but if a large number of castings are required it is policy to make a pattern that will save time on each mould in the foundry, even although it means a more costly pattern. *The word pattern throughout this paper is intended to include coreboxes.*

By far the largest number of patterns are made of pine, which if well seasoned can usually be relied on to keep its shape under fair conditions; it is fairly easy to work and will clean up with a smooth face. For small and medium-sized patterns, and where a fair number of castings are required, mahogany or other hardwood is often used, it is more costly than pine and the pattern takes longer to make, but it gives longer service.

Fragile patterns from which large numbers of castings are to be manufactured are made in metal, principally aluminium, brass and iron. Aluminium is very useful as it is not too heavy and can be worked up with little difficulty, whilst brass is also useful for small patterns, and, as it can be brazed, alterations can be easily made if necessary. Its weight, however, is a disadvantage. Iron, too, is heavy and takes much cleaning up to make a nice pattern. If the moulder has to lift the pattern by hand it is policy to keep the weight of the pattern as low as possible to avoid unnecessary fatigue. Moreover, the resultant casting is more likely to be true to size and shape, that is why pine is so much used as it is light, and, in the case of metal patterns, aluminium has a similar advantage.

Patterns are sometimes made with the substantial parts in pine and the more fragile parts in hardwood, or where a large number of castings is required the substantial parts can be made in hardwood and the fragile parts in metal and the working faces lined with metal, especially the faces of the coreboxes. This is a method that could be adopted more frequently with advantage.

Auxiliary Material.

With regard to the auxiliary materials there is little to say. Leather fillet is now universally used, and it is thought that when everything is considered that it is the cheapest method of filleting, at least in the smallest sizes. Plastic wood can be very useful at times, but unfortunately it is spoiling the apprentices. Metal dowels and rapping and lifting plates should be used where possible, and patterns should be constructed to take the strain of lifting. A good varnish is important on wood patterns. It has two duties —to make a smooth face and to protect the wood. Is should set smooth and hard—not gummy—and be waterproof. The polish used in many shops is not properly waterproof and does not adequately protect the pattern.

A good pattern must be correct to dimensions, with proper allowance for contraction and machining; it must have sufficient moulding taper or draft; it must be made in such a way that it will stand up to the work in the foundry and keep its shape, and give the least trouble to the moulder. A built-up pattern is more likely to keep true-to-shape than one cut out of the solid wood, but there are exceptions.

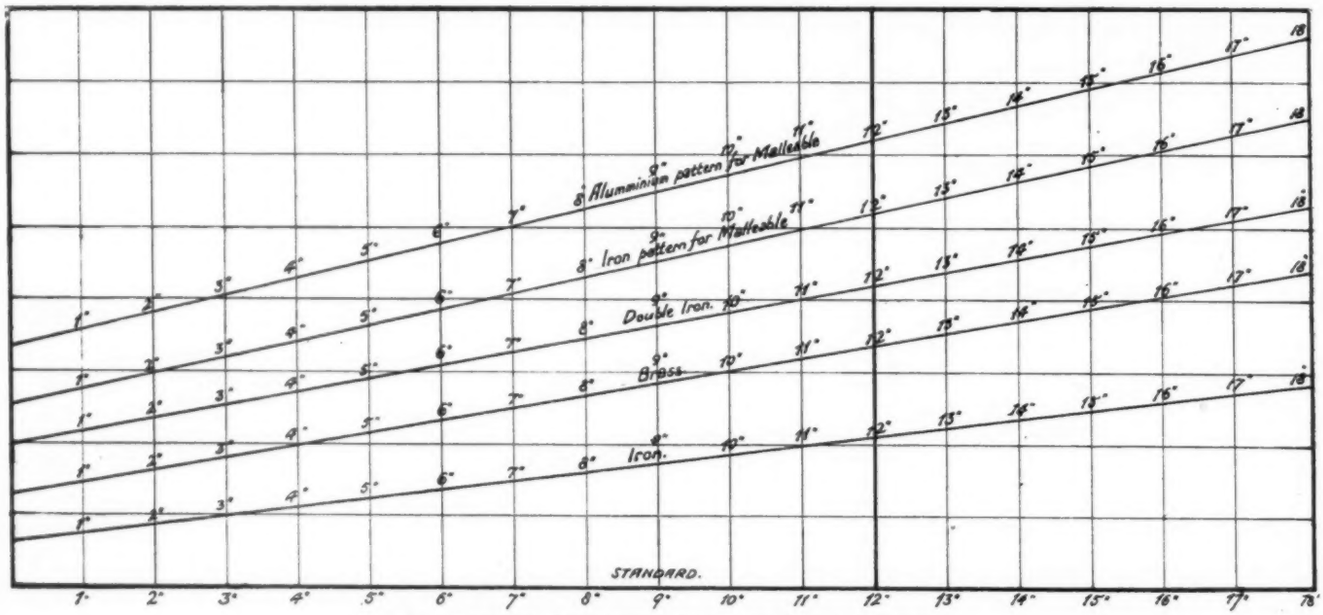

FIG. 1.—COMPOUND CONTRACTION GRAPH FOR METAL PATTERNS.

Pattern Control.

Except in the most simple pattern it is advisable for the patternmaker to set out the work on a setting-out board, working to his contraction sizes. He can then mark on the machining allowances, and, if necessary, the coreprints: he can then decide how the pattern is to be moulded. From the setting out he can see what material to cut and how to build up the job. In the case of large jobs, on which two or more men are working, the setting out should be so complete that each man can work from it without too much consultation with the others. Some firms have a special man for setting out work, but it is considered that it is better for a man to set out his own work, as he thereby becomes familiar with it and saves time on the subsequent stages.

The pattern when finished should be carefully measured up and checked by someone who has not worked on it, preferably the foreman or charge hand. The points to be watched in addition to correctness of dimensions are:—Sufficient leaving-taper, no undercut, proper filleting, whether the loose pieces can be drawn in without difficulty, whether the coreboxes agree with the prints, and whether the cores can be assembled in the mould without trouble. It is most important that patterns should be carefully checked before leaving the patternshop.

* From a Paper read last Thursday before the Institute of British Foundrymen (London Branch). Mr. W. B. Lake presiding. Mr. Furmston is the proprietor of Messrs. Furmston & Lawlor, of Letchworth.

Core Boxes.

Most of the remarks about patterns apply equally well to coreboxes, especially as to materials and finish. Coreboxes should be made in such a way that the core can be easily removed without being damaged, or perhaps it would be better to say that the corebox should be easily removed from the core, as the less the core itself is handled the better. Wherever possible, it should be made unnecessary for the coremaker to have to take out a series of screws. If there are a number of loose pieces, it is better if they are fitted to loose sides which fit in a frame box, which should be well tapered. The box with the core can be turned over on to the core plate; the frame is then lifted off and the loose sides can be removed from the core one at a time and replaced in the box, no screws being needed. On simpler boxes, hooks and catches should be provided, these save time and annoyance at the core bench, and also save the corebox from damage by dogs or hooks. This sort of thing costs a little more in the patternshop, but it is real economy in the end. It adds considerably to the life of a corebox if the wearing faces are covered with sheet metal, this is especially advisable with oil-sand cores.

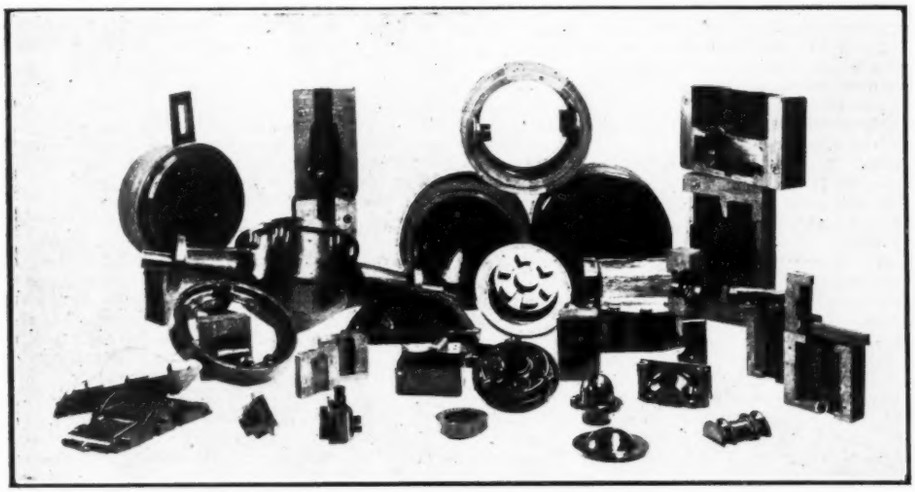

FIG. 2.—A TYPICAL GROUP OF LOOSE PATTERNS AS TURNED OUT BY A JOBBING PATTERN MAKER.

The patternshop must be in close touch with the drawing office, as drawings do not always give all the information needed. It is also often possible to suggest some modification of design which will simplify the work in patternshop and foundry without detracting from the value of the casting. It is customary in articles on patternmaking to point out the desirability of close contact between the drawing office, patternshop and foundry, but this is not always possible. Large firms possessing a drawing office, patternshop and foundry are fortunate, but there are many engineering firms who possess no foundry, and often no patternshop, yet in the aggregate these firms are consumers of a very large proportion of the castings used in this country, and they have to depend on the jobbing foundry and jobbing patternshop for their supplies. In such cases co-operation is very difficult, and generally non-existent. Where the foundry cannot be consulted, the patternmaker has to take more responsibility in deciding how to make the pattern, because this usually decides how it has to be moulded. The patternmaker's difficulty is all the greater when one remembers that the method that suits one foundry is often objected to by another.

Shoddy Patterns.

Engineering firms who do not have a large amount of patternmaking, or whose volume of patternmaking fluctuates considerably, find that it does not pay them to keep a patternshop of their own, prefering to rely on the jobbing patternmaker. Now many people associate the term jobbing patternshop with shoddy patternmaking, unfortunately there is much bad work turned out by some jobbing shops, but there are others turning out work of a very high class and equal to the best patternshops belonging to engineering firms.

It is suggested, however, that the blame for the shoddy patterns should not be laid exclusively at the door of the jobbing patternmaker, but rather that the system under which the patterns are bought is largely at fault. If there is a demand for shoddy goods someone can always be found to supply the market, in any case it can safely be said that shoddy patternmaking, however low its cost, may prove to be a very expensive luxury. Moreover, the foundries are not altogether blameless. Buyers have often said, "Why should I pay more for patterns as the foundries do not quote me better terms if I do buy better patterns?" Obviously there is a fallacy here, as a shoddy pattern may mean unnecessary weight and also much more trouble in the machine shop. Foundries could make a difference if they insisted on charging higher prices when the patterns gave them unnecessary trouble. Shoddy patterns are not likely to keep true shape, and, undoubtedly, have a much shorter life.

Metal Patterns.

Industry to-day with its large-scale production is demanding patterns that will stand up satisfactorily for a very large number of castings, and for these metal patterns are in great demand. To make a metal pattern, it is first necessary to make a master pattern. This must be made with two contractions, that is, the constraction of the metal from which the castings are to be made, and also of the metal from which the pattern is to be constructed. Moreover, all machining allowances have to be made and sufficient extra for the cleaning up of the metal pattern. Thus the metal pattern is cast from the master. This needs carefully checking to see that it has contracted as expected, and whether it has kept true to shape. If it is satisfactory, it has to be cleaned up. Sometimes an unexpected distortion occurs, and that means a lot of work that has not been allowed for, or perhaps it may be best to scrap that casting and make another. If the pattern is of such a shape that it can be easily machined, the cleaning up is easy, but many patterns are of such a shape that only finishing by hand is possible, and if done properly this is a tedious process.

When making master patterns for metal patterns the compound contractions that have to be allowed call for a special rule in order to save having to make calculations for every dimension. The author has prepared a graph or chart, actually on board, but Fig. 1 shows the idea. There were first marked all the $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 ins. up to 2 ft. on the board and squared them across. With a straight edge it was marked up to 2 ft. plus the necessary contraction. Thus for an aluminium pattern for malleable castings it would be $\frac{3}{8}$ in. per ft. or $\frac{3}{4}$ in. on 2 ft. The straight edge was then laid at an angle on the board so that the 2 ft. $\frac{3}{4}$ in. exactly laid on the 2 ft. lines squared up on the board. If a line is now drawn across the board at that angle it will cross all the $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 in. lines, and the points where they cross can be taken to give those divisions of the 2 ft. with the correct contraction allowances.

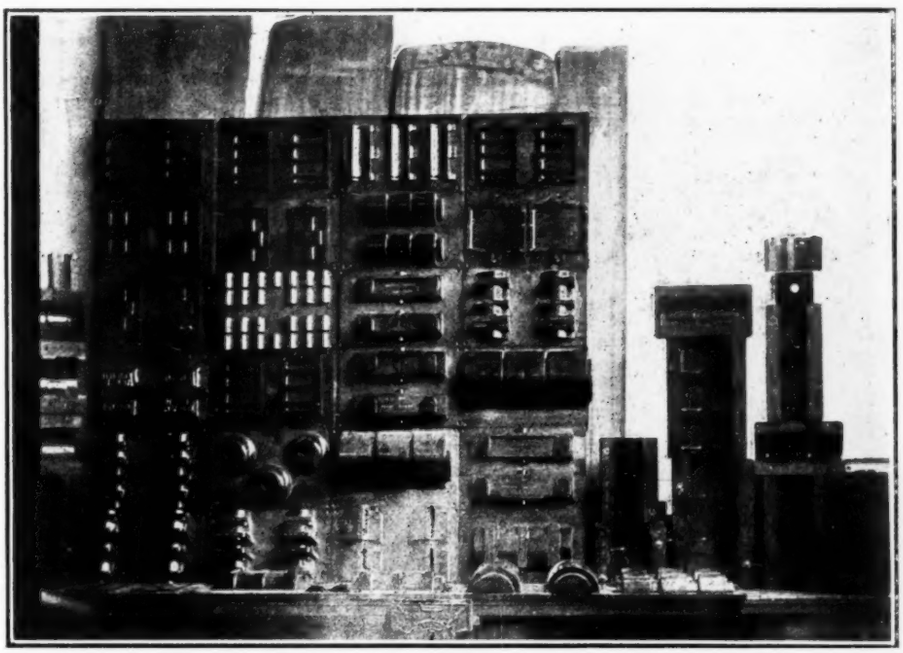

FIG. 3.—PLATE PATTERNS MADE FOR INDIAN RAILWAY WORK.

For quicker production many patterns are mounted on plates or boards, either for machine or hand moulding. Where only part of the pattern is on one plate and the other part on another plate, great care has to be taken to ensure that when the mould is made the two parts shall

correspond. The only points possible to work from are the centres of the box pins or pinholes, or some points having definite relation to the box pins. In some cases the two parts of the pattern can be mounted on the one plate, and one thus has two castings in the one box.

In the cases where the moulding joint is irregular it is possible to make a cast-plate. This is done by moulding the master-pattern and then packing the two halves of the mould apart, leaving a mould for the plate itself between. This is a well-known process, with which most are no doubt familiar. The pattern plate only comes into the patternshop to be cleaned up and drilled for the box pins if necessary.

On patterns for machine-moulding it is not advisable to have loose pieces, but rather coreprints should be put behind these parts instead and coreboxes made. Ample taper should be allowed wherever possible on all coreprints and the coreboxes made to match so that the cores are not tight until they are in their correct position, which minimises the danger of crushing or loosening parts of the mould.

A patternmaker is a skilled craftsman, but if his ability is to be used to the best advantage he must be allowed to work under favourable conditions, given the proper equipment and material. Unfortunately many firms seem to think that any old corner is good enough for a patternshop, but this is a great mistake. Good patternmaking calls for close accuracy, therefore the shop should be well lighted, it should also be well wormed and ventilated. Patternmaking is not very often a strenuous work, and men cannot work well when they are very cold and everything they touch is cold.

It is customary for men to provide their own kits of tools, but it is necessary for the firm to supply other equipment. As to type of equipment and how much, must depend on the class of work to be done and how many men are to be employed. Each man must have a bench and this should be fitted with a good vice, a universal one for preference. A lathe is necessary, for there is much turning in patternmaking. A bandsaw is a most useful machine, and no patternshop should be without one. A grindstone is also needed, for patternmakers must keep their tools sharp and in good condition, whilst a trimmer is handy.

In larger shops, circular saws, planing machines, both surfacing and thicknessing, drilling machines and disc grinders can all be usefully employed. Other machines can be obtained to suit the special requirements of any particular firm, but the above are the most pressing. It is essential that all tools be kept sharp and in good working order. It is necessary to keep records of jobs, and the author keeps his on cards similar to time cards, and the men clock on and off with each job. In most cases there is sufficient room for all the information as to material used, etc., to be put down. In large jobs the material is first written out on a larger sheet of paper and condensed. All the information is placed on these cards, including the price charged to the customer, and they are then filed away under the customer's name for future reference. Although one seldom receives inquiries for two patterns alike, it is often found that these records are very useful when estimating.

Patternmaking is most certainly a trade in which one has never finished learning, and for that reason is a very interesting one. There is so little repetition that it never gets monotonous. In the more intricate work there are always problems to solve and difficulties to overcome to keep the interest from flagging, and it does demand a combination of mental and physical activity that is very healthy.

In other branches of engineering the machine tends more and more to displace the skilled mechanic, but there are few signs of this happening in patternmaking. Better machines, it is true, are being used in patternshops, but they only do the heavy work or the monotonous work. The skilled man is still necessary to control and direct the machines and to plan the work.

Steels with High Nickel Content.

The last lecture of the "Nickel Week" recently held at the Conservatoire des Arts et Métiers in Paris, was given by M. GUILLAUME (corresponding member of the French Institut and Director of the International Bureau of Weights and Measures), on the subject of "Steels with High Nickel Content." In 1889 (he said) the principal task of the General Conference on Weights and Measures was to sanction the prototype standards of the mètre and the kilogramme which had been fixed, and to distribute these among the various States which had joined the Metric Convention. They were splendid standards, made in a platinum and iridium alloy, specially devised for the purpose by Henri-Sainte-Claire-Deville and having the X-form suggested by Henri Tresca. The International Bureau of Weights and Measures had devoted to them over three years of arduous work, which was carried out under the auspices of the International Committee. The metric system was thus effectively unified throughout the whole world.

The International Bureau, however, was immediately confronted by another problem. The platinum-iridium standards were too expensive; they cost 10,000 francs (£400) in 1889, and would to-day cost 200,000 French francs. The most accurate standards which could then be obtained—apart from those in platinum-iridium—were made of brass rules either marked directly on the brass itself or on an inlaid strip of silver. They cost 150 francs (£6), but provided little guarantee in respect of accuracy. The International Committee therefore inserted in the programme of the Bureau the study of metals or alloys suitable for making standards, sufficiently low in price to be available for institutions concerned with accurate measurements and yet providing adequate guarantees as to durability.

M. Guillaume was entrusted with this special work, and after having studied various bronzes and brasses, an alloy of copper and nickel and finally a bar of nickel submitted by the Ferro-Nickel Company, he finally came to the conclusion that this last-named metal was by far the most suitable. He would have stopped his investigations at this point if the nickel had not shown numerous microscopic pittings on its polished surfaces, and if it had been possible to make of this metal a 4-mètre bar for geodetic purposes. He therefore sought other solutions. One day, when a bar of 30 per cent. ferro-nickel had been supplied to the International Bureau by the Société de Commentry-Fourchambault et Decazeville, he found that it had a lower expansion coefficient than that of all other metals then known. After some time he had succeeded in completely determining the anomaly in the behaviour of nickel steels.

The most important of the alloys studied was Invar. Its coefficient of expansion in the normal state is one-tenth of that of its constituents, but may be modified. If a sample of Invar is allowed to cool slowly in the furnace its coefficient of expansion is increased; if, on the other hand, it is tempered, this coefficient is decreased; if it is hammer-hardened the coefficient is decreased still further, and in this way alloys can be obtained which contract when they are heated. They can afterwards be systematically baked, their coefficient of expansion being thus brought as near to zero as may be desired.

As the result of this property many miles of wire have been made, the expansion of which is approximately nil. It is employed particularly for geodetic measurements, which have in consequence been completely transformed by an adaptation of Jaderin's method. At present geodetic services make use of no other means; it enables 100 miles to be surveyed at the same cost as 2 miles formerly.

In the same series there is another alloy, platinite, which can be welded to glass and does away with the use of costly platinum in incandescent lamps. This alloy effects an economy which may be estimated at 100 million francs per annum. Moreover, if the expansion coefficient of alloys is considered it is found to be of a negative value between 36 and 52 per cent., and by making a suitable selection the steel for compensating balances can be replaced by a nickel-steel which completely solves the problem of the secondary error in chronometers.

The reason why Invar cannot yet be substituted for platinum in the construction of rules for the purpose of preserving the metric unit for an indefinite period is its variability, which is entirely due to the presence of carbon. But by reducing the carbon content as far as possible and by causing the remainder to be counteracted by chrome, tungsten or vanadium, the variability is eliminated. This variability is a maximum when the expansion is a minimum, and completely disappears in an alloy having about 42 per cent. nickel. Additions of some metals or metalloids, reduce the anomaly of dilatation. With 8 per cent. manganese or 10 per cent. chrome, Invar acquires nearly the same expansibility as platinum. The elastic properties are in conformity with the dilatation. Springs made of invar stiffen on being heated and a watch with an invar spiral spring goes fast when heated.

M. Guillaume, with the collaboration of the Imphy Steel Works, the Société de Commentry-Fourchambault et Decazeville and the Société des Fabriques de Spiraux, has produced an alloy with invariable elasticity, Elinvar. At present some 5 million spiral springs are manufactured annually and these no longer require the costly compensation formerly necessary, by which a saving of about 25 million francs per annum is thus effected.

The Value of Research.

The sixth meeting of the session in connection with the Co-Ordinating Committee, representing the Staffordshire Iron and Steel Institute, the Birmingham Metallurgical Society (Inc.) and the Birmingham Local Section of the Institute of Metals, was held on Saturday last at Dudley, Mr. F. S. Wilkinson presiding.

There was an open discussion on "The Value of Research to Industry," introduced by DR. D. H. INGALL, D.Sc. (County Technical College, Wednesbury, Staffordshire) and MR. A. SPITTLE, of Everitt (Allen) & Sons, Limited, of Smethwick.

DR. INGALL asserted that properly conducted research was absolutely essential to any industry, including the metallurgical industries. He did not think, broadly speaking, that research was popular amongst their industries. In a good many cases its value was not understood. Properly conducted scientific research was absolutely essential to industry. The proper use of research was not understood, and because of that it was mistrusted. He did not pretend that certain types of research were not costly. There were times when firms, particularly small firms, had not the margin of money to pay down for it, but he thought something could be done to meet this difficulty by a form of amalgamation.

In the malleable-iron industry there was the ever-present problem of peeling, and a great deal of work had to be done before the problem could be solved—probably more work than most malleable-iron firms could afford to undertake; yet, if the malleable industries would put their heads together, he felt confident that the problem of peeling would be overcome.

MR. A. SPITTLE said research was the basis of industry, which appreciated and rewarded the achievements of the research worker so long as they were practical. They could not condemn industry as a whole because a few sections failed to take advantage of what there was to gain from research. He referred to the number of associations allied with various industries which were carrying out research work, the results of which were available to those who cared to pay for them. In that district they had quite a number of small firms, built up on rule-of-thumb methods, struggling for existence. Incidentally, in the near future they would become obsolete because of larger industries, which were utilising to the best advantage scientific facts and information which were available, and thereby reducing their production costs.

The CHAIRMAN agreed that industry desired properly-conducted research, and not something of negative value. The great stumbling-block to research was the question of finance. Many firms looked upon the chemist as a luxury, and in slack times he was the first to go because he was regarded as a non-producer.

MR. P. JUMP (Messrs. N. Hingley & Sons, Limited, Netherton) said that we were a country dependent upon our exports. They had not only to consider problems as affecting one works with another, or one competitive trade with another, but of keeping up with foreigners; they found that they were spending immense sums of money on industrial research, and to maintain home industries they had to follow on the same lines.

Institute of British Foundrymen.

NEWCASTLE BRANCH.

At the December meeting of the Newcastle Branch Mr. Wesley Lambert, Junior Vice-President of the Institute, read a Paper on "Manganese Bronze," the lecture being illustrated with lantern slides, the chair being taken by Mr. C. Gresty (Senior Vice-President), in the unavoidable absence of Mr. V. Stobie. Amongst other aspects MR. LAMBERT dealt with was the apparent disfavour with which manganese bronze was viewed by many foundrymen, due to repeated failure on their part, through inexperience, to secure satisfactory castings with good test figures from "home made" metal. Emphasis was given to the desirability of those foundries inexperienced in the compounding of complex brasses of purchasing ingot metal from reputable manufacturers and of following as closely as possible the casting instructions issued by the makers of the bronze. The limits of the composition of the commercial manganese bronzes, the influence of the various constituent metals, and the physical and mechanical properties of the casting alloys both of the alpha-beta and of the wholly beta microstructure were very fully expounded; the lantern slides in this connection proving of much interest. The founding of manganese bronze received particular attention and was dealt with in great detail. Particulars of the best practice in the grading, melting, correction, and teeming of the metal, together with favoured methods of moulding, gating and feeding, resulting in the production of satisfactory castings were given, and a number of lantern slides showing details of foundry practice for the class of casting dealt with in the Paper were shown. The necessity of adequately "feeding" manganese-bronze castings was dwelt upon, and typical figures were given of the ratio of the weight of feeding metal to the weight of the actual casting as trimmed. The uses of manganese bronze for high-duty castings was also mentioned, and many machinery parts for which manganese bronze is in great favour were enumerated and illustrated by lantern slides.

Discussion.

MR. A. LOGAN said the Paper would show ironfounders that there was just as much skill in nonferrous foundry work as in ironfounding. He asked whether any brand of zinc could be used in manganese bronze, or, as he preferred to call it, manganese brass, with satisfactory results. From his own experience he had not found that to be the case, and he thought the question rather important. His reason for so thinking was that some impurities such as Pb, As, Bi, and Cd were present in certain brands of zinc to an undesirable extent, especially as some brands of zinc not of the highest quality were being marketed as such. He quite agreed with Mr. Lambert that all foundrymen should study the equilibrium diagrams and photomicrographs which appeared in the technical journals, because an understanding of those would assist them. With reference to the zinc loss he would like to know what was the normal zinc loss in the second melting. That also brought in the question of determining the zinc loss. He would be interested to hear Mr. Lambert's description of how he determined it by fractures, which he would say was a very skilled undertaking. To what extent could the zinc content be determined? With regard to the casting temperatures, the figures, so far as he remembered, were 960 to 980 deg. C., which seemed on the low side, and he would like to ask if, in casting a propeller, that would be the highest temperature.

In reply to Mr. Logan, MR. LAMBERT said that in his Paper he had emphasised the fact that if good results were essential, good material had to be used. Common brands of spelter should be totally excluded. There was little use for an inferior manganese bronze. No one would pay the price of manganese bronze if cast iron would meet requirements. Such was the care exercised by the most successful manganese bronze founders, that no constituent metal was used unless it was first analysed. With regard to zinc loss, he had also emphasised the fact that undue exposure of the molten bronze would lead to heavy zinc losses. When the metal was melted in a crucible with a few pieces of charcoal and the bottom of an old pot as a cover for the crucible, as he had described, very little zinc loss occurred. Much depended on how the furnace was working, and on the manipulation of the metal. He had known as high a loss as 4 per cent., but that was unusual, 2½ per cent. being about the normal figure. With regard to the sampling of the molten metal by means of fracture bars, he would not like to hazard a guess as to how many of such bars had passed through his hands. For large castings the metal was melted in a reverberatory furnace, and sample bars were taken during the period of melting and tapping of the metal. Metal in a wholly beta condition, upon fracture shows no appreciable sparkle, whereas a fracture of alpha-beta metal does show a sparkle. There are two means of discovering at the furnace whether the metal is in the right condition, namely, either under the microscope or by fracture. With regard to the question of melting temperatures, he had confined his remarks that evening more to large castings, perhaps because he had a greater interest in them. The temperature for propellers varied according to the size of the casting, and also the grade of manganese bronze used. He had known of propellers being cast at as low a temperature as 910 deg. C. On the other hand, most propeller founders cast at temperatures up to 980 deg. C., but very rarely above that figure. A casting temperature of 1,000 deg. C. was getting near the danger limit at which the metal would absorb large quantities of gas. He had repeatedly drawn their attention to the necessity for care in the details of foundry practice, and they might even think he had laid undue stress on some points. He knew of an actual case on the Continent where a propeller had been cast, and too late it had been discovered that a moulder had left his coat in the mould. In another case a man had left a hand lamp in the mould.

Poor Practice Yields Low Tensile.

MR. G. LILLIE said that when he started making manganese bronze many years ago it had, at his first attempt, only given six tons. He asked Mr. Lambert whether he lit the furnace and brought it to a certain heat before charging the metal or whether he charged the metal direct into the cold furnace before starting it? He also asked what method Mr. Lambert adopted in running propellers, where he ran them, how many gates and so on. With regard to one of the microphotographs which had been shown, he had noticed that it had a continual streak of alpha metal running round the grain boundary. What was the actual cause of that, and was it detrimental to the material?

MR. LAMBERT said that he could quite believe that Mr. Lillie had got a test result of only six tons in his first attempt to make manganese bronze. It was to prevent such a happening that he had gone so carefully into the foundry side of the question. It would be remembered that he had said that the test-bar pockets on a casting must be placed in such a position that they would be adequately fed with clean metal. If not sufficiently fed a "drawn" bar would result, from which a true test of the metal could not be expected. He did not know whether it was fully realised how difficult it was to secure a marine propeller casting that would resist erosion, as distinct from corrosion. The metal which stood up best to erosion was manganese bronze. Erosion was said to be due to vacuum cavities forming in the water and collapsing with such force on the surface of the propeller that the metal was hammered out. With reference to Mr. Lillie's other questions, the metal was sometimes charged with the furnace cold, at other times the furnace would be hot. A single runner was used for propellers unless they were exceptionally large. The metal shown in the photomicrograph, referred to by Mr. Lillie, would not give a very good test. That particular slide had been taken from a piece of metal of unknown source which had caused an accident; the design of the casting having been calculated on the metal being of the specified strength. He would always reject manganese bronze which gave a microstructure such as the one in question.

MR. LAMBERT was asked if he could give an illustration of how to cast manganese bronze in a jobbing shop in such a manner as to do away with the necessity of putting a head right along, as had been shown in one of the slides. He replied that manganese bronze must be adequately fed. In the case of large propellers weighing, say, 20 tons, upwards of 5 tons of feeding metal had to be cut off, and small castings must have a similar proportion of feeding metal. The contraction was such that an adequate amount of feeding metal must be employed. The runners were quite small, but the head was large. Even quite small castings must be properly fed to obtain good results.

Erosion Overcome by Design.

MR. CARR asked if they could take it as a fact that high-speed propellers which had been running for some time would have cavities, caused by erosion, at the boss.

In reply, MR. LAMBERT said that if the casting was not a clean casting anything might happen. Speaking particularly of a clean propeller casting fitted on a new ship, he had not yet come across anyone who could foretell with certainty where erosion would take place. All one could do was to wait until the ship had been at sea, and then, upon discovering where the propeller was eroded, to modify to better advantage the design of any subsequent propeller required for that particular vessel.

Furnace Lay Out.

MR. W. J. PAULIN said he supposed that contraction would vary according to the nature of the casting. In such a casting, for instance, as a large wheel with a diaphragm connecting the boss to the rim, there would be considerably less contraction than in a long straight casting, owing to the fact that in the latter casting it would not be tied by the difference in the rate of cooling which would take place in the wheel. In such a case, the diaphragm cooling first, prevented the contractional effect of the rim taking place. As an engineer he had been very much interested in the photographs of bronze propellers and in the method of machining them. In one of the slides crucible fires had been shown for melting the bronze, which were coke fired and provided with a grating open to the workshop. Had Mr. Lambert ever found that the grating diminished the free flow of air to the underside of the fires, as he, Mr. Paulin, had found this effect did take place where the chimney had been rather low in height, and that a very great improvement took place when a conduit was carried to the outside of the shop and a grating placed outside in addition to those inside the shop. He also had the impression that the supply of air to the fires was considerably modified by the total volume of air available in the building itself.

MR. LAMBERT said that in his opinion one of the advantages of gratings fitted over ash pits was that the furnaces took air direct from the shop, and thus assisted in keeping sweet the atmosphere around the fires. Another advantage was that the draught could be checked if necessary by daubing over the grating in parts with loam. The fires were worked with coke, which, as a fuel, had much in its favour.

MR. GRESTY asked if, with a metal of excessive elongation, it was possible for a bronze propeller to bend under normal service stresses?

In reply, MR. LAMBERT said that a beta bronze was stiffer than an alpha bronze. If a marine propeller was likely to be knocked against obstructions, such as might conceivably happen with shallow draught vessels, it can be made of a softer and more ductile bronze, so that the damaged blades could be straightened easily. Other propellers are required to be of a metal which would break rather than bend when subjected to severe shock. There was little harm in the blades of a propeller slightly bending back-

wards and forwards in service as long as the metal was not stressed beyond its elastic limit.

Vote of Thanks.

MR. LOGAN, in proposing a vote of thanks to Mr. Lambert, said that he was sure that all appreciated the fact that that evening was the first time that Mr. Lambert had given a Paper on "Manganese Bronze" and also that Mr. Lambert had come specially from London to lecture to them.

MR. R. J. SHAW, who seconded the vote of thanks, referred to the method of taking samples from the furnace before pouring, and asked Mr. Lambert if he depended wholly on the appearance of the fractured sample for correcting any loss of zinc which might have occurred during melting, or did he estimate the copper by analysis? He thanked the lecturer for his very lucid and informative Paper.

In replying to the vote of thanks, which was passed with acclamation, MR. LAMBERT said that his visit was to redeem a promise made two years ago to the Newcastle Branch. He was more than satisfied if they had been interested in the subject matter of his lecture; judging from the discussion that certainly seemed to be the case. One object of the Institute was the enlightenment of its members as to the means of overcoming the difficulties met with in foundry practice, and to introduce as far as desirable more science into the foundry procedure than had been the case in the past. He had emphasised the desirability of all foundrymen giving a little time to the study of the theoretical side of their work, and to become acquainted with the interpretation of the published diagrams and photographs, which would not only prove of value in their everyday problems, but would afford a further interest in their work. If he had said anything which would induce anyone to study that side of foundry practice he was satisfied. With reference to Mr. Shaw's question, one used the comparison of fracture bars to determine the quality of the metal. An estimation under the microscope in the period available during which the metal was molten could be made more readily than one by chemical means.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Core Oil Mixtures.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Replying to your correspondent's criticism in the issue of January 5:

In the first place the use of naturally bonded sand is stated to be necessary *under certain circumstances;* these prevail where castings, invariably large, are cast in pre-heated moulds at a temperature well above the decomposition point of any known oil sand mixture. The necessity for such a remark and the special distinction given concerning the scope of the subject matter of the lecture arose through the author's particular knowledge of some Tyneside practice, the results of which having been seen credit is therefore duly given.

The italicising of the sentence in the first paragraph is due to Editorial appreciation of the distinction, for which many thanks.

The article does not claim entirety but "The beginning of an extensive series of practical experiments to determine the values and possibilities of all media likely to be of service to the foundrymen." No actual mixture is recommended, the results given of any particular experiments are units of one complete whole which it is hoped will be available at a later date.

I would recommend your correspondent, however, to use a practical expedient in the form of a good blacking clay-wash for any cores entirely surrounded by metal—modification of his statement would be a natural corollary.

The lack of careful reading of the article by your correspondent makes the task of replying to his criticism rather uninteresting.

The vague criticisms of the graphs makes an efficient reply impossible, as grinding of the sand grains was never anticipated in the paddle mixer, and the graphs prove that it does not take place in the mortar mill.

It is not at all unfortunate that an old type of paddle mixer was used; we are quite conversant with the new Fordath "Rotoil" mixture, and have had full access to the use of one, but I preferred not to include any results obtained from such a mixer while still in its infancy.

It is sufficient answer to your correspondent's comparison to the hay-rick that in a foundry using 80 tons of oil sand mixture per week I find coremakers passing paddle mixed sand out of preference for sand from the mills.

Your correspondent betrays an extended and very intimate interest in the one particular type of machine, a fact which cannot be dissociated from the view he wishes to put forward.

I have noted with peculiar interest the gratuitous reference to the firm of Leyland Motors, Ltd., and like the last paragraph of your correspondent's letter, it is considered as totally irrevelant to the matter under discussion.—Yours, etc.,

WALTER WEST.

The Farington Steel Foundry of
Leyland Motors, Limited,
Leyland, Lancashire.
January 17, 1928.

Cupola Economics.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—As one interested in cupola practice generally, I was pleased to see Kohlenstoffe's letter re coke ratios, in your last issue.

What he states about the ignorant buying and using of coke is applicable to most other materials used in the iron foundry. One is often staggered to think that so many of our works do not understand their cupolas. This valuable melting unit is too frequently neglected, and yet is it not the starting point of the whole firm's production?

With a better knowledge of buying the necessary materials, such as fuel, refractories, flux, etc., a tremendous economy could be made at almost every large foundry in this country. Too often is the question of initial cost per ton considered. In my opinion this is largely due to the buying department not understanding even the elementary rudiments of cupola practice. Because a coke or a ganister is low in first cost, it must, in their opinion be the most economical one to order.

My experience also shows that British founders are not out to reduce expenses. They prefer to carry on in an old-fashioned way, and because their fathers always used such and such a material, it does not occur to them that more economical materials and methods are available to-day.

Surely a lesson can be taken from the American and Continental founder who is always willing to discuss a proposition and try it out if it sounds at all reasonable.—Yours, etc.,

GERALD BROWN.

36, Victoria Street, London, S.W.1.
January 17, 1928.

An agreement has been entered into between Automatic and Electric Furnaces, Limited, London, and the Allgemeine Elektricitats Gesellschaft, Berlin, whereby this latter company will now manufacture and sell Wild-Barfield electric furnaces in Germany, Austria-Hungary, Jugo-Slavia, Bulgaria, Turkey, Greece, Roumania, China, Finland and Luxemburg. Recent orders for furnaces include:—Vickers, Limited; General Electric Company, Limited; Great Western Railway; North Western Railway (India); London Midland and Scottish Railway; Iraq Railways (Baghdad); Alfred Herbert, Limited; Imperial Japanese Government; Peel Conner Telephone Works; S. G. Brown, Limited; H. W. Caslon & Company, Limited; and Gramophone Company, Limited.

The principal German manufacturers to the number of twelve have transferred the sale of their cast steel wheels and pairs of wheels and axles to Stahlräder Gesellschaft Mit Beschränkter Haftung of their common sales office. The arrangement to commence on December 1, 1927. It comprises all cast steel wheels for light railways and collieries up to a weight of 100 kilos each and all pairs of wheels and axles with wheels up to this weight. The main German cast steel wheel manufacturers have for a good many years regulated their prices by mutual agreement, and it is for organisation purposes that a common sales office has been opened. Stahlräder are represented in Great Britain by Messrs. Gossell & Son, Limited, 110, Cannon Street, London, E.C.4.

Random Shots.

Apropos my comment of last week on the substitution of iron bars for timber for certain purposes in the Lens coalmines, I note a somewhat similar phenomenon on the South African railways, where an attempt is being made to use steel sleepers instead of wood for the same reason—the high cost of the timber. Much comment has been aroused by the fact that these same South African railways have accepted the German tender for the locomotives they are requiring, as being the lowest by a long way: but this other point, which is also of considerable interest, seems to have been generally overlooked.

* * *

The number of bankruptcies is by no means a bad guide to the general prosperity of the community, and one district has just issued some returns which are distinctly illuminating. In 1923 the total number of bankruptcies was 153, in 1924 it had dropped to 120, in 1925 the decrease was much smaller, being only to 117, while the last two years, in spite of industrial troubles, have shown a very marked improvement. 1926 shows a drop of 12 to a total of 105, while 1927 shows the further drop of 18, which brings the total for the year down to 87. Ever since this year began we have been inundated by wave after wave of faint-hearted optimism, as if people had an inner conviction that 1928 really might see an improvement, but bitter experience had taught them never to commit themselves, even in the very least degree. Figures like these, therefore, are the more illuminating and the more valuable since they speak for themselves and require no interpretation, optimistic or pessimistic.

* * *

The Christmas children's Lectures at the Royal Institution always attract a good deal of attention from the public, and with that section of the juvenile public who are lucky enough to attend them they must surely rival the fading glories of the pantomime as a seasonable attraction. This year Professor Andrade's lectures have concerned themselves with engines, and the appeal both to the general public and to that section of it for which they are primarily intended has been especially strong. In particular his remarks anent the differences between the British and the American engine have been seized upon—a topic which was briefly discussed in this column not so very long ago.

* * *

These lectures are an excellent test of a man's ability to present technical matters simply and in such a way as to interest the layman. In the present instance the simplicity required is, of course, extreme, while the layman is about as "lay" as he well could be, but for that very reason the test is the more searching. On the whole the gift seems to be a somewhat rare one—the entertaining speaker or lecturer so frequently tells you nothing, while the man whose words are full of "meat" is far too much inclined to send you to sleep before half-time. One feels this especially in the matter of broadcast talks—the popular objection to "highbrow" topics is less because they are highbrow than because they are dull, or, in other words, because the speaker is dull.

* * *

What we really need—and not only for broadcast talks—are experts in the art of sugaring the pill. Later reflection usually leads us to prefer the spoon that conveyed a somewhat substantial pill—but at the time it is essential that the jam be the dominant feature.

MARKSMAN.

Central Heating Scheme for Paris.—As previously reported, the municipality of Paris has granted to a French group a concession for the central heating of the various districts of the city. German papers now report that the concessionaires have for some time been in negotiation with the firm Rud. Otto Meyer, of Düsseldorf, who are acknowledged experts in central heating of towns in Germany.

The Selection and Use of Refractories for Iron Foundries.*

By C. Presswood, B.A.

The ideal refractory material would be as little affected by the operation of melting and casting iron and steel as is the familiar iron spoon by the melting of lead or white metal. Commercial refractories, however, are far from ideal, and are the subject of endless criticism from those who use them, criticism which is to some extent justifiable, but which should always be tempered by the reflection that so far as our knowledge goes at present there does not exist a material which is as insensitive to molten iron as is the iron spoon to molten lead.

A justifiable complaint may be made when manufacturers of refractory materials fail to make the best use of the materials which nature places at their disposal, a condition which generally arises from ignorance or carelessness. Whilst it is not intended to make this Paper an apology for the shortcomings of suppliers, it is assumed at the outset that needless trouble and complaint arises from faulty selection and subsequent misuse of refractory materials.

In discussing selection and use, it is well to bear in mind one or two premises, (a) that it is impossible to make wise selection or careful use without reference to conditions under which the refractory materials will be used, (b) that selection and use should always be based on a knowledge of the properties of the materials in question, and (c) that first cost is no criterion of the ultimate value. It is bad policy always to buy the cheapest material, and it is folly to purchase highly expensive materials if their "life" in use does not warrant the expense. Some purchasers err in the former direction, a few in the latter. In considering costs, too, it is important to include the cost of labour in making replacements, the incalculable lost profits and disorganisation whilst repairs and replacements are effected. So that, though the manufacturer may charge for a special refractory six times what he would charge for the ordinary type, the former need not give six times the life in order to justify its cost. Twice the life may in some cases be acceptable.

The true cost of refractory materials is only measured by their cost per ton of metal produced over a long period, and it is this cost which must be made the basis of wise selection.

It is sometimes worth while to increase the cost of refractories per ton of metal for the sake of regularity in material and delivery, and the foregoing remarks need modifying and amplifying when the refractory has a direct influence on the quality of the finished product. Moulding sands will probably be the case uppermost in your minds. In a case like this it is not generally wise to consider the materials merely on a basis of cost per ton of finished castings, since the better, and probably more expensive, moulding sand will produce a more attractive and reliable casting which sells more readily in the face of competition—a fact which can hardly be valued, but which must be considered. There should be more figures of true cost of refractory materials available as they would greatly assist manufacturers in making improvements and in marketing new materials.

Desirable Properties.

What are the conditions which a refractory material may be called upon to withstand? Briefly summarised, they are:—(1) Intense heat; (2) chemical action of slags, ash, gases, etc., commonly called "fluxes." The damaging effect of these is due to the fact that they combine with the refractory material to form compounds which are very easily melted, and the thin slags thus formed easily penetrate far into the refractory, particularly if this be porous; (3) physical and mechanical conditions such as heavy loads, abrasion, "flow" and "wash" of thin and viscous slags and metal; (4) changes of temperature, which are sometimes very sudden; (5) oxidising and reducing atmospheres, and, lastly, one might add, (6) rough handling before use.

All these affect refractories in iron foundries and generally two or three act simultaneously.

Selection and Use.

Selection, as well as use, must be based on the criteria by which refractory materials are judged, and these may here be briefly summarised and explained.

They are:—(1) Refractoriness; (2) thermal expansion—reversible and irreversible; (3) degree of firing to which burnt refractories have been subjected in manufacture; (4) spalling propensities which are estimated by (a) porosity, (b) texture, and (c) density—apparent and true, from which porosity may be deduced; (5) crushing strength, and (6) analysis and mineralogical constitution, both of which are important, since it is clear that two materials showing approximately the same chemical analysis may have widely different properties in consequence of different mineralogical constitution.

The term "refractoriness" is difficult of definition, but is generally taken as the temperature at which a specimen shaped particularly as a cone (Fig. 1), bends to a certain extent (Fig. 2).

TEST CONES.

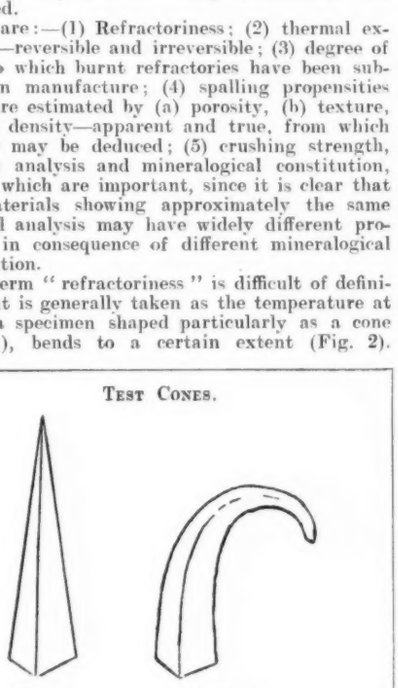

FIG. 1. BEFORE FIRING. FIG. 2. AFTER FIRING.

The method of temperature measurement should be fixed, and it is well recognised that, amongst other factors, rate of heating has great influence on the result. Moreover, the conditions in the test furnace are not comparable with those in industrial furnaces, and consequently a figure indicating "refractoriness" must be taken with a certain amount of reserve.

It is, however, quite certain that "refractoriness" does not mean "melting point." In fact, refractory materials, being rarely pure substances, but very complex mixtures, have no definite melting point in the sense that pure ice has. Nor is the refractoriness the same thing as "softening point," since the test cone may be soft long before it bends. Viscosity of the soft refractory is important here as well as texture, and it is clear that of two test cones of different materials, placed side by side in the furnace, one may be soft before the other, but may not be the first to collapse. In other words, the material which softens first may prove in the test to have the higher refractoriness.

Since refractory materials generally soften far below the temperature indicating their refractoriness in standard test, this temperature must be well above that at which they are to be used. The temperature difference between first signs of softening and final bending of the cone may be as much as 300 deg. C.

Fortunately there now is at the disposal of foundrymen a test which, though open to some criticism and imposing conditions on the test-piece by no means identical with actual furnace conditions, does more nearly approximate to a practical test. The test is known as the "under-load" test, and gives a figure far more reliable in estimating the probable value of the material in service.

In this test the material to be tested is carefully cut and ground to shape of a prism 3½ in. by 2 in. by 2 in. It is then heated in a specially-designed furnace, generally electric, and so designed that during the whole range of heating a constant load is applied to the specimen. The prism, of course, changes in volume, but the weight system is so devised that expansion and contraction do not alter the load. The material ultimately becomes so soft as to be incapable of supporting the load and it collapses. The temperature is carefully measured by pyrometers at regular intervals throughout the test, and as far as possible a standard rate of heating is maintained. The temperature at which collapse takes place is known as the "under-load refractoriness," and may be expressed as degrees Centigrade or Fahrenheit, or as Seger cone equivalent.

A further refinement consists of a recording needle and chart, the needle being fixed to an arm which transmits the expansion and contraction movements of the specimen to the needle. An expansion curve results, from which the temperature of collapse may readily be deduced, as shown in Fig. 3.

In comparing figures for different materials due attention must be paid to conditions such as load, rate of heating, and so forth. Thus, in America, the under-load test specifies 25 lbs. per sq. in. In this country the load adopted is 50 lbs. per sq. in., a figure which covers all loads carried by refractories in industrial furnaces. Unfortunately there is as yet no universally accepted specification of test conditions, so that the difference between figures for two different samples may not be a true indication of their relative value.

Effect of Atmosphere upon Refractoriness.

Generally speaking, oxidising atmospheres are best for refractories, especially if they contain ferric oxide. The laboratory tests already mentioned clearly indicate that refractoriness of materials containing ferric oxide is considerably lowered by a reducing atmosphere, *i.e.*, an atmosphere of hydrogen or carbon monoxide. The presence of these gases indicates that there is an insufficiency of air (or, more scientifically, oxygen) for complete combustion. The effect on refractoriness can be interpreted simply as follows:—

Ferric oxide in the refractory is reduced to ferrous oxide, a form in which it readily combines with the other fluxes and silica, to form complex silicates whose fusion point is very low, much lower than the corresponding compounds formed by ferric oxide. There are figures available which give the reduction in refractoriness caused by various percentages of ferric oxide, but these may here be passed over with the deduction that if refractories are to be used in a reducing atmosphere they should not contain more than 1 per cent. Fe_2O_3.

Volume Changes with Temperature.

These are very important, and whilst the actual figures of coefficient of expansion are of more interest to furnace designers and to users of furnaces, such as the open hearth, than to iron foundrymen, the relative values and general differences between various classes of refractory materials should be known. A point, important, and not always fully appreciated, arises here.

Whilst, in comparison with metals, refractories may be said to have little or no expansion with heat, yet they do all expand and contract as temperature rises and falls, just as does a bar of iron. Whereas the expansion of silica bricks is large and important, that of sillimanite bricks is infinitely small, and can almost be neglected. This expansion and contraction is called the "reversible thermal expansion," reversible since the expansion on heating is, or should be, equal to the contraction on cooling back to the original tem-

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* A Paper read before the Bradford Branch of the Institute of British Foundrymen, Mr. W. Parker presiding. The author is on the staff of the General Refractories Company, Limited, of Sheffield.

perature. The "reversible thermal expansion" is important and can be accurately measured in the test furnace.

But it is commonly found that after a specimen has been heated and allowed to cool, no matter how often, it never recovers its original size and it is "permanently" smaller or larger. This "permanent" change in volume is called the "after-expansion" or "after-contraction" and is of great importance. It is due to the fact that in heating all refractory materials, chemical and physical changes take place. These are often very slow and heating has to be stopped before they are complete. They are "arrested" reactions, and subsequent heating and cooling tends to carry them further. Now the nature and extent of these reactions with their attendant volume changes varies widely from one class of brick to another. By careful manufacture it is possible almost to eliminate the "after-expansion" and "after-contraction" (up to temperatures of 1,400 to 1,500 deg. C.) and the "after-expansion" test is therefore valuable as a guide to the care with which burnt refractory materials have been manufactured. This test is usually standardised as heating the specimens up to 1,410 deg. C. at a rate of 50 deg. per 5 min., and holding at that temperature for two or four hours. In such a test, a badly-made firebrick would contract and a silica brick expand.

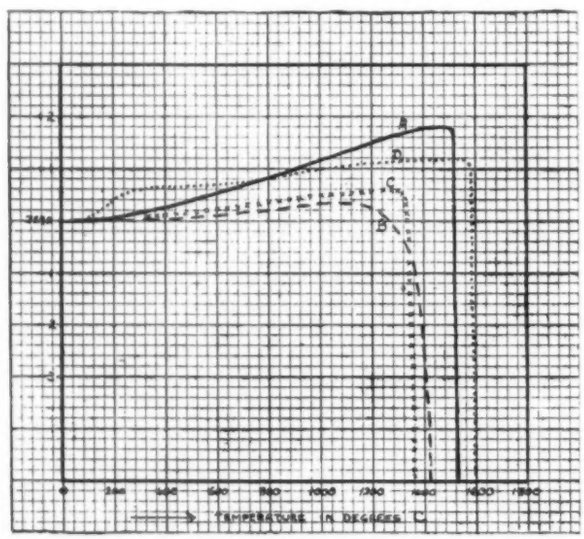


FIG. 3.—BEHAVIOUR OF REFRACTORY MATERIAL UNDER INCREASING TEMPERATURE CONDITIONS.

(The above curves are not true copies of actual results, but are representative.)

A.—Expansion regular and collapse sudden, i.e., softening occurs within a small temperature range. This is advantageous (given by magnesite brick).
B.—Expansion small and even, but collapse is gradual, and softening occupies a wide range of temperature. This is a disadvantage (firebrick).
C.—Also a firebrick, but softening occurs within a smaller temperature range and collapse is more sudden. Note.—Although A softens first, it does not collapse so soon as B, and is therefore regarded as being the more refractory.
D.—An uneven expansion which necessitates careful heating in the neighbourhood of 200 to 300 deg. C. (Comparable with silica brick.)

Whilst this feature applies only to burnt shapes such as cupola bricks and blocks, and not to raw mixtures, it should be emphasised that the value of many pastes, cements, ground ganisters, compositions, etc., is dependent upon the amount of burnt material which they contain. This material, called "grog" by the firebrick manufacturer, has been shrunk or thoroughly expanded before incorporation in the mixture. It lessens the shrinkage or expansion of the composition in question.

Since linings expand and contract under load when in use the value of an underload expansion curve is apparent.

Selection of Burnt Raw Materials.

In the selection of burnt refractory materials, the extent to which these have been fired in manufacture is very important and is largely indicated by the tests just described. Some of the constituents of a refractory which has been overburnt may have melted, and the material, on cooling, contains a fair proportion of "glass." It is, in consequence, often liable to spall if used in conditions which encourage this feature, namely, alternating temperatures.

Spalling.

Spalling is a common feature in materials which have high expansion or contraction, whether reversible or permanent, but the tendency to spall is greatly reduced if the material can expand or contract freely. Generally this is not the case when bricks are built into furnace walls even if "expansion joints" are provided. The texture of a brick is important in this connection and must be judged by grading and by density (apparent and true) from which the porosity may be deduced. Pore spaces in a brick may be regarded as tiny expansion joints, whence has arisen the idea that a porous brick is less liable to spall than is a dense brick. This is not always true, and it is, in fact, possible to argue that the converse holds.

But density is highly important in another connection. Brickwork has generally to resist mechanical wear, such as abrasion and other factors enumerated previously, and to do this it must be mechanically strong.

Mechanical Strength.

Mechanical strength is to some extent incompatible with high porosity, the former being generally the more important, and indicated in crushing strength and underload tests. It is clear that of two bricks made from identical material and submitted to underload test, that which was badly made would fail at lower temperature. In other words, the cold crushing strength of refractory bricks is important.

Chemical Analysis.

The last, but not the least important criterion is chemical analysis. Generally the only data available when examining refractories are chemical analysis and refractoriness.

Refractory materials can be broadly grouped on a basis of chemical constitution. Three large groups are acid, neutral and basic, terms which, though based on simple chemistry, are far from simple when applied in this connection. In these groups there are smaller groups, such as silica, siliceous, fireclay, chrome, carborundum, bauxite, magnesite. Chemical considerations are primarily of importance in deciding which type of refractory is best suited to resist the chemical conditions of any particular foundry operation. Thus, silica bricks are best suited to withstand the acid and siliceous slags in the acid open-hearth process, whilst for the basic process a basic brick such as magnesite is necessary. Some type of chrome bricks have been found effective in resisting both acid and basic slags, since they are chemically neutral.

Having decided upon the type of refractory needed, the chemical analysis of materials of that group, submitted to the prospective user, is of great value. Each type is characterised by a predominant mineral. Thus silica characterises a silica brick, magnesia a magnesite brick, alumina and silica (jointly) a firebrick. (The term firebrick is generally to be understood as meaning a fireclay brick.)

In "siliceous" bricks and firebricks and cupola patching pastes, the proportion of silica and alumina are of prime importance. The other constituents revealed by analysis are generally—but not always—harmful, and an accurate chemical analysis serves to show whether the predominant mineral will be adversely affected by an excessive amount of other constituents, commonly known as "fluxes."

Since refractories are far from conforming to the ideal, it is essential that they should be selected and used with due regard to their properties, physical and chemical, and the conditions under which they are to be used if the best results are to be obtained. Whilst there are cases, like the acid and basic open hearth, in which chemical considerations definitely call for a particular type of refractory, there are others in which chemical considerations have to give way to others of greater importance.

Refractories generally used in iron foundries may be grouped as follows:—(1) Linings for cupolas and other melting furnaces, and for annealing ovens; (2) ladle linings; (3) refractory sands for moulding; and (4) specialities, such as paints, blackings, compositions, and so forth.

Cupola Linings.

The conditions, enumerated earlier, applying to this case are:—

(*a*) *Intense Heat.*—The temperature is less than that in the open hearth, but is still very high. It may be assumed that refractory linings in cupolas are exposed to a temperature of 1,600 deg. C., with higher temperatures than this locally.

(*b*) *Chemical Action* of basic fluxes such as lime, acid fluxes such as silica, present on all pig-irons, and, in addition, fluorspar, which will flux almost any type of refractory. Add to these, sulphur, and chemical conditions assume a formidable aspect for both acid and basic fluxes are at work.

(*c*) *Physical and Mechanical Conditions.*—Whilst the actual weight on the lining is not great, it has to withstand heavy mechanical wear, due to the descending charge of coke and metal, whether scrap or "pig." In the bosh or well or receiver, the bricks on the slag line are affected by "washing" action, which is as serious mechanically as chemically.

(*d*) *Temperature Changes.*—The arrangement of the charge as it descends may cause a blast of cold air to play at intervals upon a hot face, but more serious still is the fact that the whole lining is heated up quickly, from cold to hot in a few hours, and it is cooled in a similar period at the end of the day's "blow." Linings may even be chilled by a stream of cold water. Few users of cupolas find it possible to work continuously or economical to raise or lower the temperature slowly at the beginning or end of the day. In a few cases, cupolas are worked continuously until the lining demands attention, but even these continuous periods are very short and may be measured in days since cupola linings are at present unsatisfactory.

One might say that in cupolas conditions are less favourable to refractory linings than in any other furnace, and since, from the point of view

of the melter, reducing atmospheres are preferable, the lining is sacrificed to the metal.

The atmosphere in a cupola is not easily controllable, since before the CO_2 formed at the tuyere level has risen far it meets hot carbon and is reduced to CO. In the average cupola this CO may be seen burning above the charge, at the charging-door level. Now the heat generated by this burning CO is lost in ordinary cupolas, but it is learnt that in the Poumay modified cupola this waste is avoided, the CO being burnt before it leaves the charge. A diversion here is worth while, since the Poumay cupola will serve as an illustration of how conditions, together with a knowledge of refractory materials, should be studied before final selection is made.

From theoretical considerations one would deduce that the temperature in the melting zone of the Poumay system cupola is lower than that in one of ordinary type. But the atmosphere is deliberately adjusted so as to be "reducing," that part of the air necessary to complete combustion being introduced at a higher level through the small, helically-arranged tuyeres, so that the lower temperature may be more than counterbalanced by the effect of atmosphere. The author is at present investigating the use of special refractories in a Poumay cupola, and is told that the fluxing of the lining, though severe, is no worse than obtained before modification. Results so far obtained, whilst not entirely successful, are sufficiently so to warrant further trials.

Air and Reverberatory Furnaces.

These possess the advantage that the charge with its fluxes is not dragged over the whole lining. The heating flame has an easier passage, since it passes *over*, and not *through*, the charge, and is more regular, and the atmosphere may be oxidising without affecting the metal, since this is protected by a layer of slag. The effect on the slag line refractories will, however, be more severe.

Annealing Ovens.

The most serious requirements are, presumably, air-tight joints and brickwork, having little or no expansion and contraction, both of which would produce disruption of walls and arches.

Ladle Linings.

Whilst fair refractoriness is required, the temperature is only that of molten metal, and there is no cutting flame or effect of "atmosphere." The most serious considerations are:—(*a*) ability to withstand sudden heating and chilling, and (*b*) mechanical strength to resist the "wash" of metal. A special case arises when metal is desulphurised in the ladle, particularly if alkali be used for this purpose.

Moulding Sands.

In iron-moulding sands the foundrymen require:—(1) Refractoriness, in virtue of which the sand is not affected by metal under load, and stripping is thereby facilitated; (2) mechanical strength which is given by "bond"; and (3) permeability to gases escaping from the metal as it cools, and which is by no means the same thing as porosity. It depends on:—(*a*) Grain size and ratio of grain sizes (generally there should be a predominance of two grain sizes, relatively large grains and small grains); and (*b*) bond, which should not be excessive, and should be evenly distributed over each grain.

Silica Sands for Mixing should be high in silica, and therefore refractory, and should have little or no bond, and the grains should be round, even, and approximating to one size, especially if the sand is to be used for core work.

Cupola Linings.

A study of conditions leads to the conclusion that the most satisfactory lining should be:—Neutral; able to withstand temperature changes without spalling; dense; hard; mechanically strong; and refractory.

These requirements have led to the general use of firebricks as cupola linings, a choice which can be justified by consideration of their main features. They are, moreover, among the cheapest of refractories. It still remains to be proved that more expensive, special refractories, such as chrome, magnesite, carborundum, can be used with true economy, that is, with reduction in cost per ton of metal melted.

Now firebricks are only neutral in the sense that silica and alumina, acid and base, are present in chemically-equivalent proportions, and the ideal firebrick contains these two constituents in such proportion that neither is present in excess (*i.e.*, in the "free" or uncombined state). In such bricks the percentage of alumina will not be below 35 per cent., and will generally be above this figure.

Since excess silica will generally be present in the free or uncombined state it is liable to expand when the brick is in use, and the tendency to spalling is thereby increased. The burning of firebricks in manufacture is not generally designed to convert the free silica to forms in which its expansion is not so serious. The presence of free alumina is not always an advantage, although high alumina bricks are generally more refractory than those containing 35 per cent. or less. Many firebricks are made from mixtures of ordinary firclay with bauxite or bauxitic clays, both of which are rich in Al_2O_3. This mixing of two different materials, which may have different expansions, means that temperature changes may disintegrate the brick. This is not to be interpreted as a sweeping condemnation of this practice since wise makers carefully select the clays to be mixed and, whether by research or by trial and error, they find clays which will blend satisfactorily. It is, however, advisable not to be blindly enthusiastic about high alumina bricks as they are more expensive than ordinary firebricks and often give no better service in use.

Firebricks quite commonly develop sillimanite ($Al_2O_3 . SiO_2$) and mullite ($3Al_2O_3 . 2SiO_2$) during use in furnaces, and these minerals are now receiving attention as refractory materials. They are formed in firebricks by inter-reaction of silica and alumina under continued high temperatures, and are characterised by high refractoriness and very low thermal expansion. Whilst part of the value of high alumina firebricks may be due to the probable formation of these minerals, this is not to be read as an assertion that sillimanite or mullite bricks (high-priced specialities) will prove successful as cupola linings. Quite the converse is indicated by the author's present knowledge.

So that, in selecting firebricks for cupola lining, the ratio of silica to alumina, as revealed by chemical analysis, is worthy of serious consideration. To derive real benefit from such considerations, however, a full knowledge of the chemistry of clays and mixtures of silica and alumina is necessary and it is doubtful whether research has proceeded far enough to standardise any conclusions in this matter. There are, moreover, firebricks in which the SiO_2/Al_2O_3 ratio does not satisfy any of the foregoing rather debatable points, and which give good service in cupola linings. The purchaser can rarely be expected to go into all this and generally wants simpler considerations.

It is essential in judging the merits of a firebrick to note that silica and alumina are the main constituents. Silica may be present in quantities ranging from 80 to 55 per cent., alumina from 10 to 45 per cent., these figures being only approximate. If alumina is above 35 per cent. the bricks are generally higher in price. It is clear that the analysis of a firebrick should show that silica and alumina are the main constituents and the total of their percentages in good bricks will not generally be below 94 per cent. The rest of the constituents are known as fluxes, and are undesirable, though to some extent essential, since they bind the brick particles together. They include ferric oxide, lime, magnesia, titanium oxide and alkalies, and the following maxima may serve as a guide in selection:—Fe_2O_3, 2.5; CaO, 1 to 1.5; MgO, 0.5 to 1; TiO_2, 1.5; and alkalies (Na_2O and K_2O), 1 to 1.5 per cent. Ferrous oxide, present in the raw clay, is generally oxidised in making. Fe_2O_3 is the most important flux if reducing atmospheres are likely to be met. A firebrick in which total fluxes comprise more than 6 per cent. would be regarded with suspicion.

A second consideration is refractoriness, and it may be assumed that a satisfactory analysis will lead to high refractoriness (in the neighbourhood of 1,700 deg. C. in ordinary test). The ordinary refractoriness figure is apparently well above furnace temperature, and one wonders why such bricks fail. Firebricks are soft, and readily collapse under loads of 50 lbs. per sq. in. at temperatures far below that which indicates their refractoriness. The under-load test is most valuable here, but not all manufacturers offer such data on their materials. A good class firebrick will collapse in the neighbourhood of 1,450 deg. C. under load of 50 lbs. per sq. in. Very good bricks would withstand 1,500 deg. C. Now this is apt to cause alarm when one considers a furnace temperature of 1,550 deg. C. to 1,600 deg. C., but the following considerations account for such life as is obtained from firebrick linings:—(*a*) The weight is rarely 50 lbs. per sq. in. In a firebrick wall, 20 ft. high, the weight on the bottom course would only be 20 to 25 lbs. per sq. in., and (*b*) it is only the inner face of the wall which is at the higher temperature, and the weight will be carried by cooler parts nearer to the shell of the furnace.

But this softening effect on the bricks is serious since the hot inner face is liable to be soft enough to hold particles of corrosive ash, dust, silica, lime, etc., and may, indeed, be so soft that the descending charge tears it away. It is quite apparent that the ideal refractory would have a high crushing strength at the temperatures met in industrial furnaces. So that, wherever figures are available, it is refractoriness under load which must be considered and that brick with the highest figure selected—other considerations being equal.

The expansion curve under load is valuable as indicating the ability of the material to withstand the temperature changes. It has been shown that this ability is estimated by expansion, proportion of "glass" in the brick, the texture, and porosity. A high expansion, or an irregular one —which can be illustrated in the expansion curves under load (Fig. 3)—will most certainly cause trouble in this connection. Firebricks are generally well able to resist spalling.

Conditions in a cupola call for dense bricks which will be mechanically strong, and will resist wear and tear due to the descending charge. They will, moreover, be less liable to penetration by fluxes. A difficulty arises here, namely, that a dense brick is more likely to spall, and selection calls for wise balance of judgment. It is arguable that a fairly porous brick could be selected from considerations of spalling tendencies, and its face protected from penetration by dust and slag by the application of a highly refractory, hard and dense, slag-resisting wash or coating, generally applied as a finely ground cement.

In the upper part of a cupola, mechanical wear and tear is very severe, and whilst at the charge-hole level, metallic blocks can be used to meet the impact of charge, between these and the melting zone very dense bricks are needed, density being here more important than refractoriness. It thus appears that at least two types of bricks could be used with advantage in the cupola. Whilst this would be inconvenient and call for special care it might be well worth while.

Ramming of Cupolas.

This is frequently used as the method of lining nowadays, and the compositions to be used must be selected with due regard to the conditions I have outlined. The main advantages of a rammed lining appear to be:—(1) Absence of joints; (2) ease with which lining is effected, and (3) repairs effected by same material, so that there is only need for one material in stock. The disadvantages would seem to be:—(1) Difficulty in drying, and disruption of the lining may follow rapid drying or melting before lining is dry, and (2) the front face of the lining is thoroughly sintered by heat but the inner parts (nearer the shell) may be friable.

If the chemical analysis of the ramming material is satisfactory, the important features to be considered are: grading, bond, and "set," when rammed hard and dried. The "bond" must be sufficient to bind the coarse particles together and no more. The bonding material must set on drying to produce a hard mass. Grading or size of the coarse refractory particles is important in producing a mass which is sufficiently porous to

dry easily, and sufficiently coarse to allow easy ramming without formation of air pockets. Grading has great influence on hardness of the dried mass. A mass of particles poorly graded will require more bond than the correctly graded mixture, and it is to be remembered that this bond is at the same time a "flux" whose function it is to bind the more refractory particles together. The coarser particles should preferably be calcined so that any permanent shrinkage or expansion is removed, and they may be either siliceous or fireclay material.

Thus, the production of a satisfactory ramming composition calls for great care and wise application of knowledge. A good composition for this purpose will not, therefore, be cheap, that is, as cheap as the common patching ganisters and compositions. The prime cost of the ramming material considerably affects the economic value of this method of lining and there does not seem to be sufficient information on which to base definite conclusions as yet.

Since the main objection to brick linings is regarded as joints it seems that more attention to these and the materials used in them would prove quite as profitable a line of investigation as that of ramming. With perfect joints, a brick lining can be set so as to constitute a one-piece lining. There is no drying or shrinkage problem; the lining is hard throughout, has been pre-shrunk or expanded as the case may be, and requires no heat to sinter it into hardness.

Very similar remarks apply to the ganisters and specialities offered for patching pastes; these are generally of finer texture than the ramming materials and should be selected just as carefully.

The commoner ramming compositions and patching pastes are siliceous, but could just as well be of fireclay. Theoretically one would expect a silica lining to be more susceptible to lime than is a fireclay, but experience in cupolas shows very little difference. Cupolas are, however, frequently bricked with "siliceous" bricks containing 80 to 85 per cent. SiO_2 and 8 to 10 per cent. Al_2O_3, of similar composition to ground ganister. They are frequently called "ganister" bricks, and the term "siliceous" includes "semi-silica" bricks. From the high free silica content one would expect these bricks to spall, but they often give good service. The non-spalling qualities of some bricks in this class has been attributed to the fact that the clay is present in sufficient quantity to compensate by its shrinkage for the expansion of the silica. Such an explanation is not always tenable, but there are others which it would not be profitable to discuss here.

This leads to a consideration of the possible use of silica bricks in cupola linings. A silica brick is characterised by about 95 per cent. silica, 1½ per cent. lime and very little else. Theoretically these bricks would be rejected on account of high thermal expansion which should cause spalling, and they are, moreover, distinctly "acid" and therefore susceptible to lime, which is, in fact, used in bonding the brick. The author would be glad of any information on this point as, so far as he knows, only one firm is using lime-bonded silica bricks for lining a cupola. He has no details as to manner of working, or results obtained, but he would suggest that with the properties of these bricks in mind, they are unsuitable for lining cupolas which are worked intermittently. There are wide differences between different makes of this class of brick, and one type he has in mind has certainly very low spalling propensities—as is proved by its use in regenerators and checkers.

Special Refractories for Cupolas.

Whilst there are references in technical literature to the use of such special refractories as chrome, magnesite and bauxite in cupola linings, the subject has not been fully investigated. These materials may fail when tried in the usual form, but may possibly be specially adapted so as to give better results.

One further essential in cupola refractories is that the bricks and blocks used must be of good shape and regular in size, and must be carefully jointed with good jointing material. There is no doubt that joints are usually the starting point for slag penetration and wearing of the linings.

For Air Furnaces the selection of firebricks is to be made with the same care. It is still more practicable in this case to use bricks of medium porosity and low spalling tendency, for roof and side walls, and then to close the pores by a refractory coating on the face. Only the highest class firebrick should be used. Special refractories, though very expensive, might yet be worth while in this case.

Annealing Ovens. These do not generally call for the highest grade firebrick yet selection here should be made with due regard for conditions. When these are considered it will be seen that in view of the alternate heating and cooling silica bricks are most likely to spall. With ordinary care firebricks, carefully built, will give such a long life as does not warrant the use of special, high-priced refractories. Joints are often the weakness here because temperature is not high enough to glaze the fireclay commonly used, which, in consequence, imparts no mechanical strength to the structure and renders the joints very weak in addition to being leaky, admitting air, etc. In a case like this it is best to use one of the cold setting cements, or a less-refractory clay.

Ladles.

It is a strange circumstance that the best quality firebricks often fail in a ladle lining.

Remarkably good results have been obtained by the use of firebricks made from rather poor fireclay and underburnt. The explanation would seem to be that an underburnt firebrick contains no "glassy" material, which is a feature of all well-burnt bricks, and, of course, spalls under the sudden temperature changes in a ladle. In iron foundries, however, ladles are more commonly lined with loam, ground ganister, and specialities. These must be fairly refractory, must dry hard (not friable), must dry without shrinkage. Ideally, they should be just so refractory that the heat of the metal sinters the skin.

In some foundries it is usual to desulphurise in the ladle, and this may be effected by the use of carbonate of soda or specialities incorporating this material. But the alkali very quickly attacks a loam, firebrick, or ganister lining, and in one or two places desulphurising by this method is not adopted simply because of lining troubles. It is possible, however, to use specially made compositions which have been known to increase the number of heats in desulphurising from 5 to 200.

Silica Sands.

Silica sands, generally used for cores and for mixing with strong-bonded moulding sands, should be as nearly pure silica as possible. They should be free from bond, the grains round, and all approximating to the same size. In this way maximum permeability is ensured. The grain size should be chosen to suit the class of work on which the sands are to be used.

Moulding Sands.

These are characterised by high silica content, but must also possess bond, which is given by both alumina and ferric oxide. A bond due to hydrated or colloidal Fe_2O_3 is to be preferred to that given by clay, since the bonding power of the former is not so easily destroyed by heat as in the case of the latter. Sands whose bond is colloidal ferric oxide do not tend to become "spent" so soon as those bonded by clayey matter. The content of ferric oxide is not harmful in this case, since there is no effect due to "atmosphere." Bond should be evenly spread over all grains; there should be sufficient to give strength and no more, except in the case of sands to be used as renovators. Fluxes, as shown by chemical analysis, should be low. Selection should always be made from such sources as can be relied upon for regular and uniform deliveries. A high-class sand is of no use if only available occasionally.

The Use of Refractory Materials.

No matter how wise and successful the selection, the last word is said by the user—that is, the actual furnace operator, melter, or moulder, who can make or mar the best materials, and who can achieve wonders from material which is theoretically poor. Respect for these users is increased when it is remembered that they have done their job for years without any theoretical knowledge, such as the technology of refractory materials. To some extent they work by "rule of thumb," and their knowledge of the different treatment refractories will withstand is based on actual experience, and not on any theoretical chemical and physical knowledge.

The technologist, in one sense, seeks to find the reasons for the conclusions reached by the practical man, and in making his pronouncements and opinions should show deference to practical experience. Knowledge of refractory materials is so little advanced that theoretical conclusions are often shattered in a practical test. The practical man should not, on the other hand, despise the theorist, since technology aims at such grouping of practical conclusions that general rules are formed by which the knowledge gained by experience can be imparted to a learner in a few years.

Refractory materials are most likely to give full satisfaction when the theorist and practical man work together. Each should try to appreciate the other's point of view, and the practical man will benefit just as much by a knowledge of technology as will the technologist by practical experience.

Since the "user" has such power, he has also great responsibility, and he should see to it that refractories are used with due regard for their properties. In other words, the farther refractories are from the ideal, the greater endeavour should be made to "give them a chance."

Bricks should be handled carefully. The author often contrasts the meticulous care with which one handles postage stamps, and the annoyance one shows if a penny stamp is torn, with the rough and careless handling which firebricks receive. The cheapest firebricks cost more than a penny each, but magnesite bricks, worth 1s. 6d. each, are often handled as though they were common building bricks. The manufacturer is horrified as he sees the shapes, the perfecting of which has haunted him night and day, being broken on corners and edges by careless handling. Bricks should be carefully handled, not merely so as to avoid grieving the supplier, but because, with damaged edges and corners, it is impossible to build furnace walls, in which joints are so thin as to be almost invisible.

New brickwork and patching should be perfectly dry before heating—a point not always appreciated. It is arguable that refractory bricks, like common bricks, give better and stronger walls if they are wetted before being set in fireclay or cement. This is worth careful investigation, as it receives support from researches into the effect of using wet grog in firebrick manufacture. If such practice is followed, the drying before firing must be the more thorough. Patching materials should be applied with the minimum of moisture, must not be applied to glazed or slagged surfaces, the surface to be patched being cleaned or "scrappled," so as to enable new material to "key" on to the old brickwork. The cleaned surface must be wetted, preferably with a thin wash of the material, before the stiff paste is applied. Patching materials should be applied in as thin layers as possible, and the thicker the patch the coarser the materials. Finely-ground material should be carefully vented.

In some foundries the cupola lining is cooled by a spray of cold water or a dusting of lime at the end of the day. This is not giving the linings a chance, and though it may be essential in some cases, it is apparent that another cupola is called for.

Linings can be quickly ruined by the use of excessive flux, such as limestone and fluorspar, and these should, of course, be used in the minimum quantities consistent with requirements in the metal. Metal a little cooler and slag slightly more viscous may be less costly than the wear and tear of linings.

Careful charging of a cupola will produce that regular and even arrangement of charge which will facilitate passage of blast and preserve the lining, in addition to producing more efficient melting. Ladles should, of course, be pre-heated wherever possible, so as to reduce the thermal shock to the lining.

If the most refractory and the densest firebricks are selected with a view to resisting heat and slag action, it is clear that they must not be encouraged to spall and *shattered by sudden heating and cooling.*

Moulding sands should be used with the utmost care, being well mixed and well milled so as to

spread the bond uniformly, and carefully rammed, neither too hard nor too soft. Excessive "sleeking" brings clay and silt to the surface of the mould, and refractoriness and permeability are thereby reduced, and "scabbing," "burning on," are caused.

Careful use of furnaces means that less of the lining is reduced to slag, in which both fuel and metal are wasted.

The whole question of selection and use calls for wise judgment and ability to compromise, and the need for knowledge and care, is all the greater, since the demands upon refractories are great in comparison with their ability to meet them.

Wise selection will enable the user to select the right type of material and to discriminate between good and bad supplies of that type. Careful use, on the other hand, will ensure that the material selected will give good service.

Discussion.

The PRESIDENT said Mr. Presswood had covered an extremely wide field on his subject. Personally, he felt that the branch would welcome, on a future occasion, a Paper by the author on one particular aspect of the various matters he had covered in the important question of refractories. They, as men keenly interested in moulding, would be glad to hear the views of a man of the knowledge of Mr. Presswood on, say, sand in the foundry.

MR. WHITTAKER (of Bradford), proposing a vote of thanks to the lecturer, said the address that day had been of fascinating interest alike to the practical foundrymen and the chemists present. Perhaps the majority of the members of the branch were practical foundrymen and they would certainly be glad to hear a Paper by Mr. Presswood devoted especially to moulding sands.

MR. W. H. POOLE (Keighley Laboratories, Limited), seconding, said Mr. Presswood had dealt with his vast subject in a manner which all interested in foundry work could appreciate and understand. He had undertaken a difficult subject, but had treated it in a very lucid manner, and had gone through a remarkably extensive range of phases of the subject—a range which was rather astounding in so short a time. Mr. Presswood was to be congratulated on the way he had got the lecture together on so wide a field and had reduced it to an exposition which was simple enough for all concerned to understand without any difficulty.

MR. PRESSWOOD, replying to the vote of thanks, said he had the greatest respect for the men who were the practical users of refractories, but he believed refractories were in many cases not given quite the chance which was their due. He knew that some of the manufacturers at times felt quite grieved at some of the unkind things said about these refractories, because if the refractories were given a little more thoughtful treatment they would return better service. He hoped that anything he had said that evening might do something towards leading to a general better understanding of refractories among the men who used them.

MR. S. W. WISE (Bradford) said there were certain phases in relation to refractories which were necessarily beyond the experience of the average iron founder, and they looked to technical men like Mr. Presswood to impart guidance and knowledge on these phases. His address and his subject had been of particular interest to the members of the West Yorkshire branch of the Institute because they had recently been discussing the relative merits of rammed lining as against firebrick lining in cupolas. Some members had suspended judgment, and they all realised that there was much to be said in both directions, and much still to be learned. Mr. Presswood's observations seemed rather to suggest that if one had a rammed lining one was practically turning the furnace into a brick kiln. In the experience of most of the members of the branch, rammed linings had proved successful in some foundries, but yet it seemed rather contrary to the theory now put forward, if one could take the material from which firebricks were made and put it into a furnace more or less correctly rammed: the dragging of the template through the length of the furnace must lead to inequality of the ramming. From what they had heard that evening from Mr. Presswood it would not seem feasible that a rammed lining could be as good as a brick lining when put in correctly. Mr. Wise said it would be very beneficial if Mr. Presswood could on some occasion give some further talk on that subject in particular.

MR. POOLE, referring to the question of spalling on a cupola lining, said he believed there was a good deal more of this occurring—apart from actual melting of the brick—than was generally understood. There were more cases of too-refractory patching being put in than of poor refractory patching. For annealing furnaces and for others he had himself, for many years past, made a practice of heavily glazing the brick as a protection against spalling. It was astonishing how much extra life was obtained once a brick was well glazed, and this applied also to the jointing materials. This value of glazing would apply also to rammed linings. Much could be said as to how to perfect a rammed lining to prevent certain troubles which took place in firing it initially. In regard to the question of silica bricks in cupolas, Mr. Poole said there must be pretty continuous running, and under such conditions one could get remarkable life out of silica where a firebrick would fail; but for general foundry work that did not apply. Mr. Poole said he would very much like to hear Mr. Presswood give a lecture on nothing else but moulding sands. The points he had raised as to iron bonding were of very great importance, and they would all like to hear Mr. Presswood in greater detail on that matter. Finally, he asked whether the author could give any idea of a reasonable amount of virgin sand per ton of finished castings, to ensure a really good finish?

MR. PRESSWOOD said suppliers would welcome more information on the cost per ton of castings produced. In two cases of steel castings which he had in mind it had worked out at 25 cwts. of sand per ton of steel. He could not give a figure, off-hand, in regard to iron castings. One heard a great deal about one sand doing one thing and another achieving something else, but he thought it was difficult to arrive at any general basis. Referring to the remarks of Mr. Wise on rammed linings and brick linings, Mr. Presswood said the opinion he had given in the address was his private opinion. If a rammed lining was to be successful there were so many factors to be controlled that it must be prepared so very carefully that its cost was certain to rise. On actual cases of which he was aware, he could not find that it was more economical to put in one or the other at present because of the care required in preparation. In some furnaces rammed linings were essential, and that certainly was so in electrical furnaces.

MR. WISE, remarking on Mr. Poole's question as to the weight of sand per ton of castings produced, said it must be remembered that the major proportion of virgin sand was in the facing sand, and that that depended on the thickness of the casting. The weight of sand used also depended largely on the character of the casting. Most founders did keep account of the amount of new sand they used per ton of castings produced, and he thought no hard and fast rule could be laid down. Some used 3 to 1 mixture and others a 10 to 1 mixture in a facing sand.

A MEMBER: Something depends on the men and how far the sand mixture is away from the work.

In view of the shortness of time, the Chairman—with the approval of Mr. Presswood—invited members who had further questions or comments to make them in writing and send them to Mr. Presswood, who would endeavour to answer them through THE FOUNDRY TRADE JOURNAL.

Strength and Structure of Cast Iron.

Many investigators are of opinion that the strength of cast iron is controlled by the constitution of the matrix, whereas the size and the distribution of the graphite flakes are only of secondary importance. According to this opinion a cast iron, the matrix of which entirely consists of pearlite, has to be aimed at, as the pearlite is the constituent which shows the best mechanical properties. On the other hand, there are some investigators who suppose that quite the reverse is the case, *i.e.*, the size and the distribution of the graphite control the strength of cast iron. Bardenheuer* checked the latter view by varying the size of the graphite flakes, the matrix remaining the same. Recently G. Neumann† made experiments starting from the other side. By quenching and annealing cast iron he succeeded in altering the constitution of the matrix, the size of the graphite remaining nearly untouched. The composition of the cast iron used was T.C. 3.4, CC 0.48, Si 1.69, Mn 0.83, P 0.42 and S 0.08 per cent. The iron was poured into dry-sand moulds, the dimensions of the test bars being 25.6 in. long and 1.18 in. dia. After having cooled the bars were heated to 850 deg. C., and quenched in oil; then they were annealed to such a degree that their Brinell hardness figures were from 146 to 165 t/sq. in. The bars were subjected to the tensile test and to the Brinell test; the latter was taken with the 10 mm. ball and a load of 3,000 kg. for 30 secs. The test results are given in Table I. From the figures it may be seen that changing the matrix as shown by the various Brinell hardness numbers has only a slight influence on the tensile strength. In order to check the above results part of bar No. 2 was packed into ash, heated to 900 deg. C. for three times, and slowly cooled in order to get a ferritic matrix. After this treatment the bar had a Brinell hardness of 113.5 t/sq. in., and a tensile strength of 11.42 t/sq. in., compared with 137.8 t/sq. in. and 11.75 t/sq. in. respectively in the untreated condition.

TABLE I.

Bar No.	Untreated.		Quenched in oil	Annealed.	
	Hardness, t/sq. in.	Tensile strength, t/sq. in.	hardness, t/sq. in.	Hardness, t/sq. in.	Tensile strength, t/sq. in.
1	138.5	11.43	273	169	13.28
2	137.8	11.75	289	146.8	13.78
3	131.5	12.58	—	153	11.75
4	129.5	12.25	—	160	13.78
5	125.1	—	—	154.3	11.5

Lancashire Foundrymen Criticise American Methods.

(*Continued from page* 48.)

about costs. One chart showed that labour cost 44.9 per cent.; material 36.05 per cent.; administration, depreciation, selling, etc., 19.05 per cent. That information was given very freely to the men in the shop, together with a considerable amount of the firm's routine and business through bulletins. The bulletins were posted up for anyone to read; they not only told workers about their errors and how the errors could be avoided, but also creditable performances.

The methods adopted for training apprentices were similar to those operating in this country. The Carnegie Technical College at Pittsburg was similar to the Loughborough College, and they were training apprentices for industry on a large scale. Since the immigration of skilled moulders from this country was stopped there had been a shortage of skilled labour. The bulk of the rough laborious work in the foundry was done by negroes or immigrants from hot climates.

The electro-magnet operating a drop bell he saw used in three foundries. It was quite clean in its operation, and he saw no sign that it was liable to pick up scrap.

* "Stahl und Eisen," 1927, pp. 863.
† "Stahl und Eisen," 1927, No. 39, pp. 1,606/1,609.

Lancashire Foundrymen Criticise American Methods.

Following a lecture* upon "Foundry Practice in the United States," by MR. E. LONGDEN, given to Lancashire Branch of the Institute of British Foundrymen, the following interesting discussion took place. It was opened by

MR. SHERBURN, who said that a Paper of this type was often difficult to deal with in discussion. Mr. Longden had ably expounded the principles of mass production and specialisation, but for the present, at any rate, it was not in the power of the man in charge of a foundry to put them into practice; his business was to make the things that were demanded of him. These doctrines should be preached to the captains of industry, the men who controlled management and determined business policy. For that reason it seemed to him Mr. Longden had the wrong audience; his Paper would be read with more advantage at a meeting of an employers' association. He did not suppose there was anyone in charge of a manufacturing organisation who did not appreciate that advantages could be gained by specialising and adopting correct methods of planning work, but he could only do his best as far as circumstances permitted, and it did seem that in regard to the use of standard articles there was a great difference between the American and the Britisher. How far that was due to a difference in mentality he did not know and did not propose to investigate; it was a psychological question. From the point of view of production no one present doubted that good results could be obtained by the methods outlined by Mr. Longden, but was it practicable to adopt them in this country? Some foundries were handling upwards of 2,000 different patterns in one week. It was not easy to see how such a position could be brought down to the few simple operations in production as had been illustrated.

Quantity Production Retards Change of Design.

Standardisation might be carried to such a degree as to prevent or hinder development. In a well-known make of motor car all the parts were standardised in their relation to each other, and a change in one involved a complete reorganisation of the whole system of production. Therefore old designs were retained in use for long periods. Until recently that car was being supplied with an engine which was 20 years old in design. This position being apparently due to the intensive organisation preventing the substitution of later and more modern mechanism.

Thus organisation might become the master instead of the servant, and care had to be taken in order that a correct relation was maintained in the elements concerned.

MR. J. MASTERS said one British firm which used prepared sand had made great progress during the last few years. All the moulds were made with that particular sand, there being no backing sand, and no difficulty had been experienced. They did not get the work through in anything like the time Mr. Longden had suggested, 20 hours; apparently that was confirmation of the remark that it took three times as long in Great Britain.

The electro-magnet for lifting pig-iron and scrap was quite good up to a point, but in six cases out of seven when they went to pick up the bowl of the magnet they picked up scrap with it. He had observed that happen in Sheffield, and a good deal of trouble was caused thereby.

Mechanical Equipment the Paramount Factor.

MR. W. JOLLEY said he did not agree with any suggestion that the American foundryman did a great deal more work than the Britisher. He saw no evidence of such. What he did see was that where an enormous amount of money had been spent on plant, etc., there was a bigger production at the end of the day, but that was not due to efforts made by the moulder. Many of the American shops were of a poor type. In his opinion American foundries could be classified in two categories; they were either very good or very bad, there appeared to be no medium. In the fettling works of one firm the conditions were very bad, both as regards ventilation and light. Castings were carried over half a mile on the carriers, and he had been informed that the distance was now doubled, the telfer tracks travelling over three buildings before reaching the fettling shop. The castings were cored and fettled and shipped on the truck ready for the next department, and they were not touched by hand.

He agreed with Mr. Longden that the sand-slinging plant at the motor works was a very elaborate mechanism. One thing that he particularly noticed was the absence of sand, and in going through that part of the foundry one would find sand only in the moulding boxes. He did not know whether Mr. Longden visited the Westinghouse works in Cleveland. The sand-mixing plant there was very elaborate and the same could be said of a works in Philadelphia.

Elimination of Backing Sand Desirable.

Mr. Longden had made quite a good point in his reference to the question of backing sand. The system followed in this country of mixing sand was often overdone. Matters would be simplified, and it would be better for the product, if instead of having mills to which the material had to be carted they adopted some kind of mixer and used a moulding sand in its entirety instead of having facing sand and backing sand. Many troubles were due to this cause. They had a nicely tempered facing sand for about an inch near the pattern, and then they filled up the back with a sand which perhaps had 30 to 40 degrees more moisture than it ought to have. By the time the job was cast the moisture had travelled through to the mould. There was much to be said for some of the methods followed in America, and if the British foundryman was given the same facilities he would be quite comparable with the American foundryman. He observed that wherever they found a Britisher in an American foundry he was very often carrying a good job.

Perfection in Foundry Lay-Out.

MR. W. H. MEADOWCROFT gave an account of his work in American foundries, and said as far as his experience went, no matter what the job was, the British moulder was as good as the American, if he was given the same opportunities. But the conditions under which the work was done were very different in the United States from those which prevailed here. It seemed to him what was wanted was a man who had no imagination and not much knowledge, but did what he was required to do and no more. It was very difficult to get the Britisher to go out of the accustomed rut.

There was a great difference in the quality of the sand. In America it was very coarse and tough. He had never come across its like elsewhere.

One reason why American foundries had progressed, perhaps the chief reason, was that engineers had arranged the foundries in a way which greatly helped the workmen. That could also be done in this country if the engineer was given scope.

Scope for Composite Metal Castings.

The CHAIRMAN (MR. J. S. G. Primrose) said there was no doubt that people in this country had a good deal to learn in regard to the use of mechanical power to help the foundryman to carry his job through and get a bigger production. How extensively that was done in the United States was indicated by the figures given by Mr. Longden, who estimated that, taking an average, 3½ h.p. to 4 h.p. was at the disposal of every worker.

There was no immediate prospect of the combination of manufacturing concerns being carried out in Great Britain to the extent to which it had been carried in America. But the question might be asked, if the general public received any benefit from these combinations, but judging by what had taken place in this country the reply must be that they do not.

The use of two grades of metal in a casting was an interesting problem. It might be possible in some cases to combine a close-grained metal with another of an ordinary type. He could not say it would be useful for Diesel engines, angle irons, etc., but there must be many machine parts, *e.g.*, lathe beds, and so forth, where only one face was required to be machined and the rest was only a support.

Some of them would like to hear more of the reported American discovery that by adding an alloy to the metal in the ladle to precipitate carbon an excellent pearlitic iron was produced where otherwise the metal would be a white iron.

In this country foundrymen were very chary of duplexing with cupolas and electric furnaces. The electric furnace itself was hardly economical as a melting medium, but as a refining agent there was a great deal to be said for it.

Author's Reply.

MR. LONGDEN said Mr. Sherburn had suggested that difficulties arose from extreme standardisation. When a design was altered it did not necessarily follow that the plant must be altered; it was not limited to one particular casting but had a certain range and within that range changes could be made without the plant requiring to be altered.

American Wages.

He was in agreement with Mr. Jolley in believing the British moulder was quite equal to the American moulder, if not superior. He could work quite as hard, and if given the same facilities he would beat the American. But the latter undoubtedly had a great advantage in the machinery which was placed at his disposal. Then the relations between employer and workmen were of a more cordial character than was usual in this country. There were not so many trade-union restrictions, and the higher wages paid was another reason which stimulated them to produce more than the British moulder. The rates for moulders averaged 40 to 46 dollars (between £8 and £9) per week. Piece workers earned as high a figure as £18 per week. The rates for labourers was from £5 to £7 per week. These conditions were made possible by the foresight exercised by the employers and by allowing freedom of thought amongst the men as to production methods.

Production Figures.

He did not think the ordinary working man in this country would be averse to specialisation so long as it gave him a decent livelihood. When the low wages ruling here were compared with the large sums earned by foundrymen in the United States it was evident there must be something in the American conditions which helped materially. The effect on production was very marked. At one foundry working repetition and jobbing castings moulders were producing in a day 12 to 14 castings similar to a small Smith's Hearth Hood in boxes 2 ft. by 3 ft. by 2 ft. 6 in., by means of loose-pattern ends rammed on an oddside. The facing and backing sand was prepared for him. In the Ford foundry something like 310 motor-car flywheel castings were produced per hour on one of the units. He did not know how many men were engaged on the particular unit. In Cleveland one man in a day made 150 boxes, 16 in. by 22 in. by 12 in. deep. Conditioned sand was supplied to the moulder. At Buffalo, working on a group of moulding machines, 8 men made 1,800 boxes per day, 12 in. by 12 in. by 26 in. That was an average of 225 boxes per man.

Such results indicated that it paid to put down the plant which enabled the workmen to earn large sums, and give a good return to the employer. While doing justice to the merits of the British foundryman, the ability of the American jobbing moulder craftsman must not be underrated. He was not far behind.

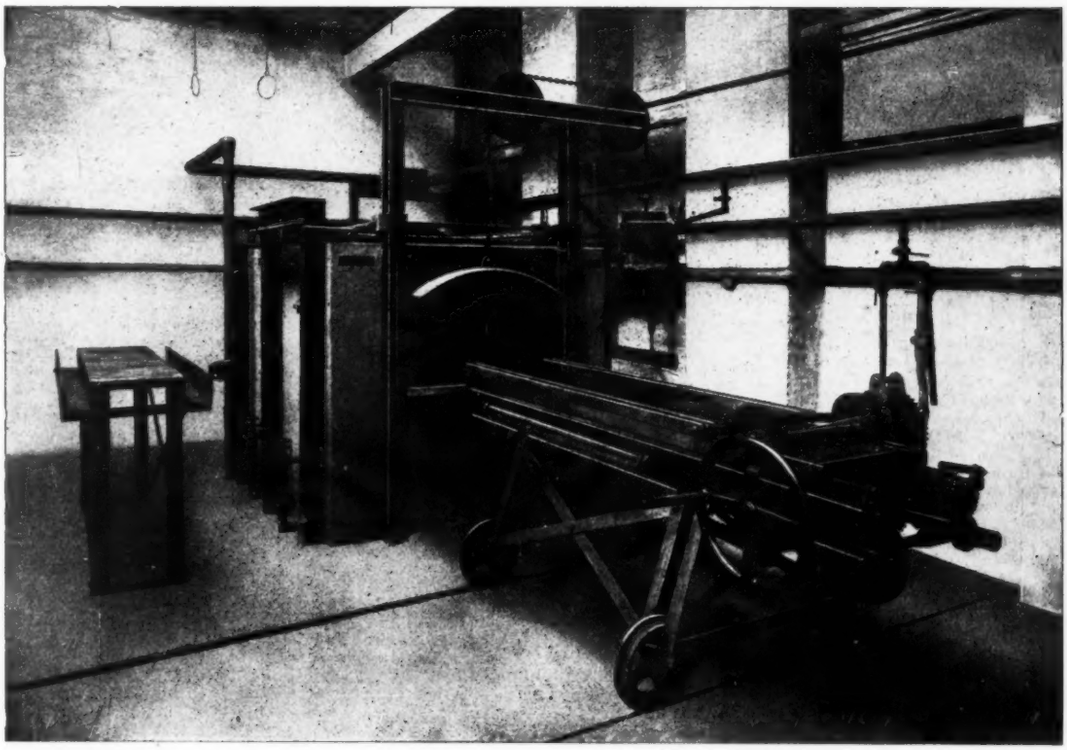
Percentage Costs.

He could not give any figures as to average costs, but the members might be interested in seeing a bulletin issued by the Nugent Steel Casting Company, of Chicago, in which they sought to educate the men in the foundry as to why wasters were produced. They also gave information

(*Continued on page* 47.)

* "Foundry Practice in the United States," by E. Longden. Published in our issue of December 27, 1927.

HEAT TREATMENT UNDER IDEAL CONDITIONS



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Trade Talk.

WRIGHT'S FORGE AND ENGINEERING COMPANY, LIMITED, Tipton, Staffs., announce that the address of their London office has been changed to 120, Bishopsgate, E.C.2.

THE BRITISH AGENCY for Leitz productions, conducted by Ogilvy & Company, 20, Mortimer Street, London, W.1, for many years, has now been taken over by E. Leitz (London) at the same address, under the direction of Mr. J. W. Ogilvy.

DIFFICULTIES OF MODERN heavy machinery transport were described by Mr. Alexander Polson, traffic manager of Messrs. C. A. Parsons' Heaton Works, at a recent meeting of the Newcastle Association of Foremen Engineers and Draughtsmen.

THE CRAVEN AND WYKEN COLLIERIES, near Coventry, have been closed down, and the plant acquired for dismantling purposes by Thos. W. Ward, Ltd., of Sheffield. The plant includes haulage gears, generating sets and motors, locomotives, pumps, winding and miscellaneous plant.

K. MALMBERG, LIMITED, 110, Cannon Street, London, E.C.4, importers of ferro-alloys, Swedish iron and steel, etc., have decided to establish an office at 2, High Street, Sheffield, to which address the department dealing with the above-mentioned lines will be transferred as from January 16.

THE RIVER WEIR COMMISSIONERS have decided to spend £18,580 on electrical equipment at the Hendon and Hudson docks, and from £1,500 to £3,000 in removing the invert at the Hendon Dock junction gateway. They have also decided to lengthen the Hendon Dock foreshore breakwater at an estimated cost of £5,000.

NEWTON, CHAMBERS & COMPANY, LIMITED, Thorncliffe Ironworks, near Sheffield, have appointed Mr. E. A. U. Ward, of the White Building, Fitzalan Square, Sheffield, as the agent for the general centrifugal casting products of the Thorncliffe Centrifugal Casting Department in the Lancashire—South Yorkshire area.

THE SECRETARY of Jonas & Colver, Limited, of Sheffield, has issued a communication to creditors stating that as a result of the losses sustained during the coal strike and consequential losses, the company has to obtain additional financial assistance. While this is being arranged, the debenture holders have appointed a receiver to protect the assets of the concern.

RD. JOHNSON, CLAPHAM & MORRIS, LIMITED, have taken a much larger stand at the British Industries Fair than last year. They will show "Jacem" brand dead flat galvanised wire netting, woven wire and wire work of all descriptions, copper wire—bare, tinned, S.C.C., D.C.C., strand, miners' lamps, steel wire, etc. They will also have a wire drawing machine in operation and a loom producing woven wire.

THE HEMATITE MIXED NUMBERS pig-iron ascertainment for November and December, 1927, which governs the wages of iron-ore miners in Dalton and district, is 73s. 11.33d. per ton, this showing a decrease of 1s. .09d. per ton below the last price of 74s. 11.42d. per ton. Consequently wages will be, according to scale, from the beginning of last week (January 9) as follows:—Miners bargains, 7s. 4d. per shift ("equal to" reaches 73s. 9d. but does not reach 75s.); miners minimum, 6s. 7d.; enginemen, no change; other surface wages, 1d. per shift (for those over 16 years). This, of course, does not apply to those covered by other special agreements.

J. HINCKLEY & SON, 11, East Parade Chambers, Sheffield, have been appointed selling agents for Pease and Partners, Limited, for "Skinningrove" rolled steel joists and sections, and for James Dunlop & Company, Limited, for steel plates and pig-iron. In order to render the best possible service, the company have opened a branch office at 1, Dickinson Street, Manchester, under the supervision of Mr. G. F. Enticknap, who during the past nine years represented Robert Heath & Low Moor, Limited, in the Manchester district. The two agencies mentioned above were previously held in the Manchester district by Carrick & Brockbank, Limited, who have now retired from business.

A SCHEME for the further education of boys and youths engaged in rolling mills in Birmingham has been approved by the associated manufacturers in the non-ferrous metal trades. Although not compulsory, it is provided that all boys (over 14 and under 17) and youths (over 17 and under 20) should attend classes at the evening institutes, and in certain cases at the technical colleges. It is also proposed to arrange a special course in metallurgy at the Central Technical College, provided sufficient students are forthcoming. Students will pay the usual fees, but these will be refunded by the employers' committee to all those who attain a certain standard of attendance and proficiency. In addition to refunding class fees the employers' committee offer prizes for attendance and home work.

Contracts Open.

Bristol, January 30.—30 portable automatic sacking-off weighers for granaries, for the Port of Bristol Authority. Mr. T. A. Peace, chief engineer, Avonmouth Docks, Bristol. (Fee £3, payable to the General Manager and Secretary, Docks Office, 19, Queen Square, Bristol; it is returnable.)

Buenos Ayres, March 15.—24 cranes (steam, diesel and electric) for the Directorate-General of Navigation and Ports of the Argentine Ministry of Public Works. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. (Reference A.X. 5.741.)

Folkestone, February 1.—Cast-iron goods, iron and ironmongery, etc., for one year from April 1, 1928, for the Town Council. Mr. A. E. Nichols, borough engineer, Municipal Offices, Folkestone.

Hereford, January 21.—400 tons of cast-iron water pipes of 3-in., 4-in., 5-in. and 6-in. diam., to the British standard specification, for the Town Council. The City Engineer, Town Hall, Hereford.

Ilkley, January 19.—800 yds. of 5-in. c.i. concrete-lined pipes and 800 yds. of 6-in. concrete-lined pipes, for the Urban District Council. The Engineer and Surveyor, Town Hall, Ilkley.

Kirkby Stephen, January 27.—80 tons of 4-in. and 3-in. cast-iron spigot and socket pipes, together with all bends, etc., the provision and fixing of a meter, valves, hydrants, etc., and the construction of a small reservoir (25,000 gallons), etc., for the East Westmorland Rural District Council. Messrs. Taylor & Wallin, the engineers, Commercial Union Buildings, 47, Pilgrim Street, Newcastle-on-Tyne. (Fee £5.)

London, E.1, January 21.—(3) Cast-iron work, etc., for 12 months from April 1, for the Stepney Borough Council. Mr. B. J. Belsher, the borough engineer and surveyor, the Municipal Offices, Raine Street, Old Gravel Lane, E.1. (Fee £1 for each tender; price of the documents, 5s.)

London, S.W., January 24-February 15.—(1) 27,638 files; (2) 790 tons structural steelwork, etc., for iron foundry; and (3) three petrol tank wagons, four-wheeled, I.R.C.A. standard type MK/1, complete with wheels and axles, metre gauge, for the Madras and Southern Mahratta Railway Company, Limited, 25, Buckingham Palace Road, Westminster, S.W.1. (Fee, £1 1s. each, non-returnable.) (Tenders due (1) and (3) on January 24; (2) on February 15.)

Melbourne, February 28.—Cast-steel dredge buckets, for the Melbourne Harbour Trust Commissioners. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 5.724.)

Pwllheli, January 30.—Construction of concrete walls, new screening chambers, outlet pipes, etc.; and providing, laying, etc., of 2,000 yds. of 6-in. and 4-in. cast-iron spigot and socket water pipes, together with all sluice valves, air valves, fittings, etc., for the Pwllheli Corporation. The Town Clerk's Office, Pwllheli. (Fee £3 3s.)

Tetuan, Morocco.—Vertical cast-iron pipes and fittings, for a contractor at Alcazar. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 5.762.)

Obituary.

THE DEATH has occurred, after a brief illness, of Mr. Leon Gaster, the founder and hon. secretary of the Illuminating Engineering Society, 32, Victoria Street, London, S.W.1 (and of its official organ, the "Illuminating Engineer").

THE DEATH has occurred at his residence in Bearsden, after a brief illness, of Mr. N. J. Kerr. He was secretary to David Colville & Sons, Limited, 195, West Regent Street, Glasgow. He became associated with the company in 1919, and on the retirement of Mr. Torrance as secretary of the company he succeeded to that position in 1925.

THE DEATH took place at his home at Ambleside, on January 8, of Mr. David Poole, who was in his 83rd year. Commencing work at the age of eight, Mr. Poole was employed at the Parkhead Ironworks, Dudley, until he was 30 years old. After seven years' service at the Leys Foundry, Brockmoor, he became manager for the late Mr. A. T. Auston at the Eagle Foundry, Brockmoor, and held the position for 42 years before retiring about 3½ years ago.

THE SUDDEN DEATH of Mr. Edgar Hodkin, of 63, Norfolk Road, will be deeply felt by a wide circle of friends. He had been in failing health for several years, but was at business as usual on Friday last, when he seemed quite normal. On Saturday afternoon, however, he had a heart attack, to which he succumbed in a few minutes. He was only 52 years of age. Mr. Hodkin was the fourth son of the late Mr. Herbert Hodkin, and was also a director of Robinsons' Brickworks, Limited, and of the Greenside Foundry Company, Limited, Chapeltown.

New Companies.

Allen Construction Company, Limited, 11, West Regent Street, Glasgow.—Capital £10,000. To acquire business at Glasgow. Constructional engineers, etc. Directors: J. L. Allan, J. R. Cross, and G. Allen.

High Duty Alloys, Limited, Trading Estates, Slough, Bucks.—Capital £20,000 in £1 shares (19,990 class "A" and 10 class "B").

John McDowall & Sons, Limited, 19, Walkinshaw Street, Johnstone.—Capital £20,000. Engineers and contractors, etc. Directors: P. Barr and T. W. Somerville.

Metallon Development Company, Limited.—Capital £5,000. Engineers' agents, etc. Managing director and chairman: E. H. S. Browne, 10, Somers Place, Hyde Park, W.2.

Henry Mills Iron Company, Limited, Sardinia House, Sardinia Street, Kingsway, W.C.2.—Capital £1,000. Director: G. H. Mills.

John A. Sangster, Limited, 5, Pittodrie Street, Aberdeen.—Capital £6,000. To acquire business of consulting and mechanical engineers, etc. Directors: J. A., J. M., and A. E. Sangster.

Sinclair Iron Company, Limited, 274, Gresham House, Old Broad Street, E.C.2.—Capital £250,000 in £1 shares. Directors: G. G. Browne, J. H. Browne (director of South British Investment Trust), H. L. Watkins, W. H. Watkins, and D. Sturrock.

Stephens Silica Brick Company, Limited.—Capital £100,000 on £1 shares (40,000 6 per cent. cumulative preference and 60,000 ordinary). To acquire business of silica brick and cement manufacturer, now carried on by Sir Alfred Stephens at Kidwelly, Carmarthenshire, as Stephens & Company. Sir Alfred Stephens, Kt., is permanent director and chairman.

Vickers-Armstrongs, Limited.—Capital £18,000,000 in £1 shares (7,000,000 "A" 7 per cent. preference, 3,500,000 "B" 6 per cent. preference, and 7,500,000 ordinary). To acquire and amalgamate all or part of the businesses, works, properties and assets of Vickers and Sir W. G. Armstrong, Whitworth & Company, and in particular certain parts therof, and to carry on business of manufacturers, sellers, maintainers, repairers of and dealers in warships and fleet auxiliaries of every description, etc.

Personal.

MR. ROBT. D. MCCOWAN, of Roseneath, Moresby, who has been appointed a Justice of the Peace, is manager of the United Steel Companies' by-product works at Lowca, and a director of the National Benzol Company.

Wills.

HOWELL, T. H., Stow Park, Newport, Mon., of Thomas H. Howell, Limited, iron merchants £69,719

Applications for Trade Marks.

The following applications to register trade marks are extracted from the "Trade Marks Journal":—

"CONSUL."—Cooking and heating stoves and ranges. Gillespies, Limited, Chattan Stove and Iron Works, Bonnybridge, Scotland.

"LE ZINC BELGE LIEGE," SURMOUNTING A HORSESHOE DESIGN.—Sheet zinc made at Liege, Belgium. L. Le Personne & Company, 99, Cannon Street, E.C.4.

"BRITANNIA."—Boilers, included in Class 18, for Central Heating Systems. National Radiator Company, Limited, Ideal Works, National Avenue, Kingston-upon-Hull.

"CONQUEST."—Grinding and pulverising mills and parts thereof, included in Class 6. Conquest Mill Engineering Company, Limited, 36, Basinghall Street, E.C.2.

"WILMH."—Finished metal castings, being goods made from an alloy of aluminium and base metal, and included in Class 13. William Mills, Limited, Grove Street, Birmingham.

"VEGA."—Non-ferrous metals and alloys included in Class 5. Maurice Herbert Cawson, trading as M. H. Cawson & Company, 59 and 60, Gracechurch Street, E.C.3.

IN HUNSLETT, LEEDS, a foundry owned by George Mann & Company, was blown down in the gale last Friday. The foundry occupies the whole length of Atkinson Street, and that part of it which crashed in the gale was some 95 ft. in length, 30 ft. high, and 30 ft. wide.

BLACKING,
PLUMBAGO,
CORE GUM,
WHITE DUST,
COAL DUST.

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PIG IRON
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J. C. ABBOTT & Co LTD
LLOYD'S BANK CHAMBERS, NEW STREET, BIRMINGHAM.
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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—With the return to normal business conditions, more activity in buying is again observable in the Cleveland iron market, and is also reflected in an increased attendance and a keener interest on the part of consumers than has been in evidence during the past month. Indications at the moment certainly point in the direction of continued improvement in consumptive demand in the near future, which must be distinctly accelerated by the increasing activity in the shipbuilding industry, and incidentally in the steelworks, which also promise an early revival of more satisfactory conditions. Another important factor in the position—the question of foreign prices—must not be overlooked, the recent advance in No. 3 Continental pig of one shilling per ton, bringing that quality material within competitive range of home producers' level. Hence merchants who have hitherto been importing on a substantial scale are not now inclined to press sales of foreign iron, and Cleveland is hopeful of getting some of the business which has been going abroad. Prices continue firm so far, current quotations ruling as follow:—No. 1 Cleveland foundry iron, 67s. 6d. per ton; No. 3 Cleveland G.M.B., 65s.; No. 4 foundry, 64s.; and No. 4 forge, 63s. 6d.

In the North-East Coast hematite market a moderately steady trade is maintained, and makers are in a less anxious position than they were a couple of months ago. They have been selling at all sorts of prices of late, and quotations are still irregular, but 70s. per ton is now an average figure for mixed numbers. On the North-West Coast, Bessemer mixed numbers are still quoted at 70s. at works.

LANCASHIRE.—Buyers of foundry pig in this area have not, so far, evidenced any keen disposition to place orders beyond immediate requirements, and business on forward account is almost negligible. Quotations are, however, steady, No. 3 Derbyshire being on offer at from 73s. to 73s. 6d. delivered Manchester or equal, Staffordshire at 72s. 9d., with Scotch brands at from 87s. 6d. upwards and Cleveland at 78s.

THE MIDLANDS.—At the quarterly meeting at Birmingham last week there were certain signs that a little more business is now being transacted, although consumers are not yet disposed to engage in large quantities for forward delivery. It has been noticeable recently that more inquiry for pig-iron has developed from the local foundries. The furnaces are not now disposed to shade their figures any further, and 64s. at the furnaces is quoted for No. 3 Derbyshire, 58s. 6d. for No. 3 Northampton, No. 3 Staffordshire is 64s. at furnace, and No. 3 Scotch is offered at 90s. delivered.

SCOTLAND.—There has been a very slow start in the Scotch pig-iron market following the holidays, the makers without exception complaining of the lack of new business. The current price of No. 3 Scotch foundry is 70s. f.o.t. furnaces, but there is very little inclination to buy even at this figure, and as a general rule consumers are only buying for immediate requirements.

Finished Iron.

In the usual order of events, the quarterly meeting at Birmingham is regarded as an index to current conditions in the iron industry, but of late has been deprived of much of its old-time importance in reflecting the position of markets for this class of material. On this occasion, in the market for finished material, there is still a wide disparity between various figures quoted for crown bars. In some directions this quality can be bought at £9 5s. delivered Birmingham, this price relating chiefly to outside districts, as some of the Staffordshire mills are not prepared to take below £10 5s. Nut and bolt iron is also in very poor demand, and the price is about £9 per ton. It is not reported that there has been any further improvement in the demand for marked bars at the lower level of £12 10s. at makers' works, but the mills making this class of material are not so badly situated for orders as the manufacturers of the cheaper qualities, and they remain fairly well occupied for the time being.

Steel.

Markets for steel, so far, have not disclosed any great improvement in the general position of the industry, and foreign competition continues unabated as the chief obstacle to expansion in the home trade. Such conditions apply more especially in regard to semi-products, there having been a little liveliness in connection with foreign material, more so than has been the case for some weeks. Continental soft steel billets are on offer at £5 4s. per ton, blooms at £4 19s., and sheet bars at £5 6s. 6d., delivered works in the Midlands. With regard to English billets and sheet bars, nothing under £6 is quoted, and now that the South Wales steelworks are better occupied, they are not quoting on a lower level than this. Of course, this figure is for the cheapest quality, and quotations for special makes vary from £6 5s. and up delivered in the Midland area. There is no change in the condition of the tinplate market, and the inquiry is fair. A moderate volume of business has been done, and the tone continues to be optimistic.

Scrap.

A rather more active buying tendency has been noted in the markets for foundry scrap metal during the current week, and at Middlesbrough consumers are taking limited supplies of heavy cast iron, paying 66s. as a delivered price for machinery quality and 62s. 6d. per ton for ordinary. Heavy steel turnings are still rather scarce at 46s., but cast-iron borings are on offer at 43s. In Scotland the holiday period being over, most of the works have made a start, and deliveries of scrap in general have been resumed. Machinery cast-iron scrap is quoted around 65s. to 66s. 3d. per ton, i.e., for pieces suitable for foundries. Heavy ordinary cast-iron scrap to the same specification is 60s. per ton, and about 58s. 6d. per ton for steelworks cast iron in furnace sizes. Old cast-iron railway chairs are 65s. to 67s. 6d. per ton, and light cast-iron scrap is 53s. 6d. to 55s. per ton. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Except for occasional downward movements, due doubtless to profit-taking by the speculative element, the position of warrant copper continues satisfactorily firm, with standard cash commanding a slight premium, whereas a year ago forward metal was practically 20s. higher than cash. Demand in Europe shows a steady expansion, and with stocks here gradually dwindling there is every indication that prices will continue on the upgrade. The feature has been the well-sustained activity on the warrant market, in which dealings each week are heavy.

Official closing prices of standard copper have been as follow:—

Cash: Thursday, £61 to £61 1s. 3d.; Friday, £61 11s. 3d. to £61 13s. 9d.; Monday, £61 15s. to £61 17s. 6d.; Tuesday, £61 12s. 6d. to £61 13s. 9d.; Wednesday, £61 7s. 6d. to £61 8s. 9d.

Three Months: Thursday, £60 18s. 9d. to £61 1s. 3d.; Friday, £61 7s. 6d. to £61 10s.; Monday, £61 11s. 3d. to £61 12s. 6d.; Tuesday, £61 10s. to £61 11s. 3d.; Wednesday, £61 3s. 9d. to £61 5s.

Tin.—Markets for standard tin at last week's close developed a further relapse in values, which declined to £250 cash and £249 forward, the lowest level reached since 1925, when at one time the spot price was down to £229 per ton. This reverse is attributed to a current rumour that there are considerable hidden stocks on the Continent and elsewhere, which, conjointly with the prospect of increasing supplies, encouraged the bears to sell freely, partly counteracted later by influential support in the opposite direction.

Official closing prices of standard tin have been as under:—

Cash: Thursday, £253 12s 6d. to £253 15s.; Friday, £250 5s. to £250 10s.; Monday, £249 15s. to £249 17s. 6d.; Tuesday, £247 to £247 5s.; Wednesday, £246 2s. 6d. to £246 7s. 6d.

Three Months: Thursday, £252 17s. 6d. to £253; Friday, £249 12s. 6d. to £249 15s.; Monday, £248 17s. 6d. to £249; Tuesday, £246 5s. to £246 10s.; Wednesday, £245 10s. to £245 15s.

Spelter.—Ordinary spelter prices continue steady at the lower range. At around the current level the market displays some resistance to a further fall, and it should respond to any improvement in the galvanising industry. The demand from the Continent for high-grade spelter of 99.9 per cent. purity lately was very good.

The following are the week's prices:—

Ordinary: Thursday, £25 16s. 3d.; Friday, £25 15s.; Monday, £25 16s. 3d.; Tuesday, £25 18s. 9d.; Wednesday, £26.

Lead.—Values of soft foreign pig since the commencement of the year have suffered a sharp relapse, and so far there are no signs of early recovery. Reports from America are not quite so good as they were recently, but the price there has been well maintained at about 6½ cents. U.K. arrivals for last month were estimated at about 20,000 tons, and new supplies accounted for in the last two months having been rather short of needs.

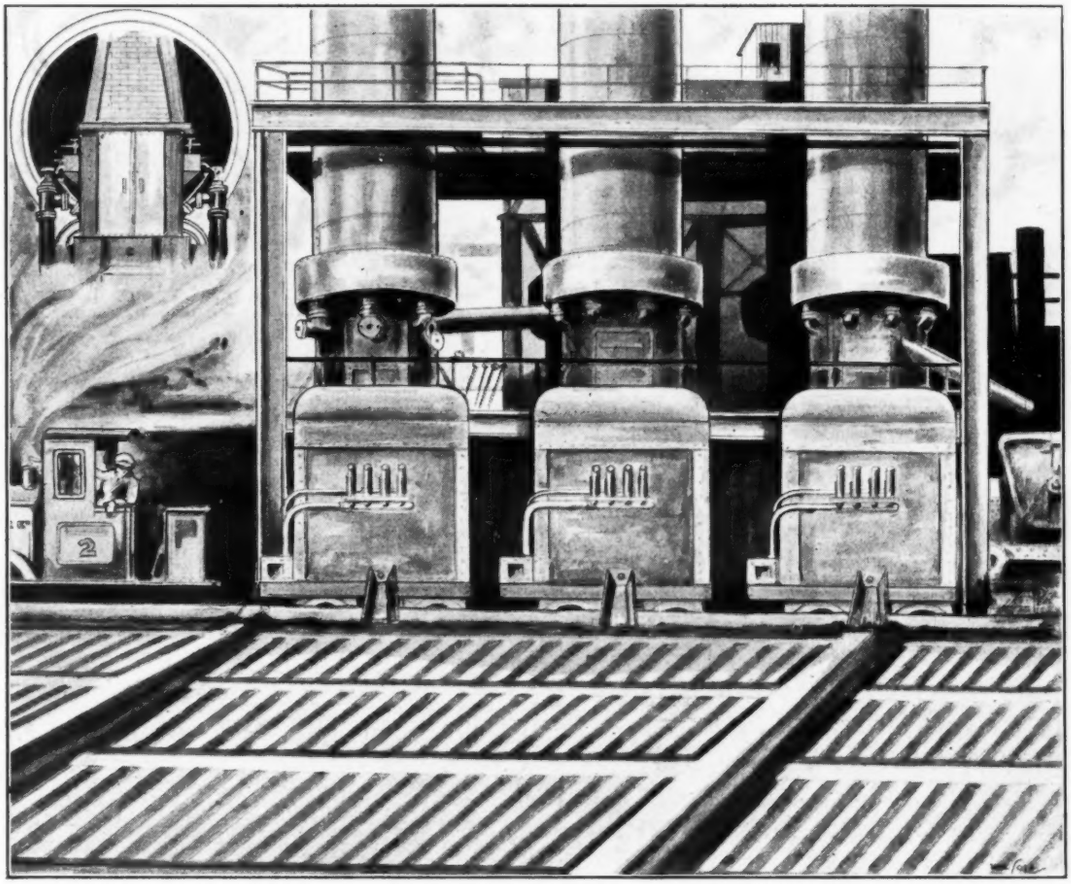
The week's prices are appended:—

Soft foreign (prompt): Thursday, £21 17s. 6d.; Friday, £21 15s.; Monday, £21 16s. 3d.; Tuesday, £21 15s.; Wednesday, £21 15s.

Metal Extrusion.

Before a meeting of the Cleveland Institution of Engineers, held at Middlesbrough on Monday, MR. J. E. NEWSON, M.Met., read a Paper on "The Uses and Manufacture of Bars, Sections and Tubes in Brass and Other Alloys by the Extrusion Process," in the course of which he remarked that the most important features of a metal or alloy intended for extrusion were that at the working temperature it should be soft, plastic, flow readily under pressure, and that its range of working temperature should not be too restricted. Brass with a composition of copper 57 per cent., lead 2 per cent., zinc 41 per cent., was an ideal alloy, and its extruding range was from 700 to 850 deg. C. As a general rule, the temperature required for extrusion was somewhat higher than that for rolling or forging the same material. The pressure available was of considerable importance, and within limits the higher the pressure the lower the temperature at which the material could be extruded. Naturally, the properties of the extruded bar were a function of the temperature at which the extrusion ended, and it was advisable to avoid the lower end of the temperature ranges where possible. Referring to the light aluminium alloys, the author said these were characterised by a rather high co-efficient of friction when hot, and high resistance to shear, making them difficult to extrude with low pressures, in addition to which they had a limited working range, and in some cases, such as Y alloy, they retained a large proportion of their strength at elevated temperatures. Their high co-efficient of friction rendered them very liable to score, and it was remarkable that this feature was very pronounced in the high-strength brasses, where it was found in practice, that the higher the aluminium content the greater the ease with which scoring occurred (particularly the bore of tubes), and the greater the resistance to be overcome in pulling the bars down the incline to the straightening plates when hot. The thermal properties of a metal must be taken into account—its specific heat and brightness of surface affecting its heating time, its conductivity affecting its rate of cooling in the container, and its co-efficient of expansion having an important bearing on the contraction allowance of the die aperture and the variation in size of the front and back end. Regarding the speed of extrusion, this varied with the nature of the metal and the size and number of holes in the die; but the normal average rate was 1 in. per sec. Extruded material (concluded the author) found a very large application in industry, forming a good starting point for many operations. Round bars or sections were cut into billets for stamping or pressing; bars and tubes were supplied for use on automatic lathes. One important use for tube was the manufacture of cages for ball and roller bearings. Sections were in great demand for electrical gear and switch parts, turbine parts, fittings for locomotives, motor transport, gun-sight and gun-mounting mechanism, gears, lock parts, hinges, metal window casements, and numerous other applications.

Cleveland Bridge and Engineering Company, Limited.—MR. J. R. DIXON presided at the 35th annual meeting at Darlington. The chairman, moving the adoption of the report, said there did not appear to have been any marked improvement in trade conditions, foreign competition being largely responsible for the cutting down of prices to a very low level. Since their last annual meeting the only contracts of any note which had been taken were further extensions and renewals of the goods station at Paddington and the reconstruction of an airship shed at Cardington. Contracts successfully completed during the year included a viaduct for the London and North-Eastern Railway at North Seaton; the first half of the rebuilding of Paddington goods station; and a mile of 9-ft. 6-in. diameter steel waterpipe at Maentwrog, North Wales.



A worthy successor to the Old Refinery Hearth

The exacting demands by engineers for high duty castings have made it essential that Pig Iron of a definite composition must be readily available. The old type refinery has had to give way to modern methods and scientific improvements in order to meet this demand. The Bradley Furnaces are daily producing special Refined Irons within fine limits of chemical composition to suit every specific job and meet every requirement in the field of engineering.

FROM
LAST WEEK'S
FOUNDRY TRADE JOURNAL

"These Special Irons constitute the classification of modern Refined Pig Irons which may be defined as those Pig Irons prepared by retreating Blast Furnace Pig Irons with the object of improving their properties, qualities and characteristics for given special requirements."

J. E. HURST.

Bradley's

PIG IRON

"A QUALITY FOR EVERY REQUIREMENT"

Write for analysis and full particulars of the Bradley range of Special Refined Pig Irons for all purposes.

BRADLEY & FOSTER LTD. BF DARLASTON. STAFFS.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	61	7	6
Three months	61	3	9
Electrolytic	66	10	0
Tough	65	5	0
Best selected	65	15	0
Sheets	92	0	0
India	77	0	0
Wire bars	67	0	0
Do. January	66	15	0
Do. February	66	15	0
Ingot bars	66	15	0
H.C. Wire rods	71	0	0
Off. av. cash, Dec.	60	2	3
Do. 3 mths., Dec.	60	5	7½
Do., Sttlmnt., Dec.	60	1	10½
Do., Electro, Dec.	66	8	4
Do., B.S., Dec.	65	9	2
Aver. spot price, copper, Dec.	60	2	3
Do., Wire bars, Dec.	66	13	1½
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			9½d.

BRASS.

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	10½d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	10½d.
Wire	9½d.
Rolled metal	9½d.
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£	s.	d.
Standard cash	246	2	6
Three months	245	10	0
English	245	0	0
Bars	248	0	0
Straits	247	0	0
Australian	247	10	0
Eastern	251	5	0
Banca	247	5	0
Off. av. cash, Dec.	267	4	10½
Do., 3 mths., Dec.	263	9	7½
Do., Sttlmt., Dec.	267	4	7½
Aver. spot, Dec.	267	4	10½

SPELTER.

	£	s.	d.
Ordinary	26	0	0
Remelted	26	0	0
Hard	20	5	0
Electro 99.9	30	15	0
English	26	7	6
India	22	0	0
Zinc dust	33	0	0
Zinc ashes	8	15	0
Off. aver., Dec.	26	4	8⅝
Aver., spot, Dec.	26	7	3

LEAD.

	£	s.	d.
Soft foreign ppt.	21	15	0
English	23	5	0
Off. average, Dec.	22	6	0⅜
Average spot, Dec.	22	3	3

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	35	0	0
Do. V.M. ex whf.	33	0	0
Rods	41	15	0
Boiler plates	30	10	0
Battery plates	32	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	64	10	0
Chinese	45	0	0
Crude	37	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	22	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%	8	17	6
45/50%	12	17	6
75%	20	10	0
Ferro-vanadium—			
35/40%	14/3 lb. va.		
Ferro-molybdenum—			
70/75% c. free	5/- lb.		
Ferro-titanium—			
23/25% carbonless	11½d.		
Ferro-phosphorus, 20/25%	£17	15	0
Ferro-tungsten—			
80/85%, c. fr.	1/3 lb.		
Tungsten metal powder—			
98/99%	1/8 lb.		
Ferro-chrome—			
2/4% car.	£33	0	0
4/6% car.	£23	0	0
6/8% car.	£22	17	6
8/10% car.	£22	5	0
Ferro-chrome—			
Max. 2% car.	£35	17	6
Max. 1% car	£41	12	6
Max. 0.70% car	£53	0	0
70% carbonless	1/4 lb.		
Nickel—99%, cubes or pellets	£175	0	0
Ferro-cobalt	9/3 lb.		
Aluminium 98/99%	£105	0	0
Metallic chromium—			
96/98%	2/11 lb.		
Ferro-manganese (net)—			
76/80%, loose	£13	10	0
76/80%, packed	£14	10	0
76/80%, export	£13	0	0
Metallic manganese—			
94/96%, carbonless	1/10 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	£	s.	d.
Finished bars, 14% tungsten	£0	2	6
Finished bars, 18% tungsten	£0	3	0

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/-lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.		£	s.	d.
South Wales—							
Hvy. steel	3	0	0	to	3	2	6
Bundled steel and shrngs.	2	14	6	to	2	18	6
Mixed iron and steel	2	15	0	to	2	16	0
Heavy cast iron	2	18	0	to	2	19	0
Good machinery for foundries	3	0	0	to	3	2	6
Cleveland—							
Heavy steel					2	15	0
Steel turnings					2	6	0
Cast iron borings					2	3	0
Heavy forge					3	12	6
Bushelled scrap					3	2	6
Cast-iron scrap	3	2	6	to	3	6	0
Lancashire—							
Cast-iron scrap					3	5	0
Hvy. wrought					3	2	6
Steel turnings					2	2	6

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	51	0	0
Brass (clean)	38	0	0
Lead (less usual draft)	19	0	0
Tea lead	16	0	0
Zinc	17	0	0
New aluminium cuttings	76	0	0
Braziery copper	47	0	0
Gunmetal	48	0	0
Hollow pewter	170	0	0
Shaped black pewter	130	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	67/6
Foundry No. 3	65/-
Foundry No. 4	64/-
Forge No. 4	63/6
Hematite No. 1	70/6
Hematite M/Nos.	70/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	83/-
,, d/d Birm.	87/6
Midlands—	
Staffs. common*	—
,, No. 4 forge	62/6
,, No. 3 fdry.	64/- to 65/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	54/-
,, fdry. No. 3	58/6
Derbyshire forge	60/-
,, fdry. No. 3	64/- to 65/-
,, basic	—
Scotland—	
Foundry No. 1	—
,, No. 3	70/-
Hem. M/Nos.	74/-
Sheffield (d/d district)—	
Derby forge	64/-
,, fdry. No. 3	68/-
Lincs. forge	64/-
,, fdry. No. 3	68/-
E.C. hematite	82/6
W.C. hematite	85/-
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	73/3
Northants foundry No. 3	—
Dalzell, No. 3	100/- to 102/6
Summerlee, No. 3	87/6 to 94/-
Glengarnock, No. 3	87/6 to 94/-
Gartsherrie, No. 3	87/6 to 94/-
Monkland, No. 3	87/6 to 94/-
Coltness, No. 3	87/6 to 94/-
Shotts, No. 3	87/6 to 94/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.		£	s.	d.
Iron—							
Bars (cr.) nom.	9	5	0	to	10	10	0
Angles						—	
Tees to 3 united ins.						—	
Nut and bolt iron					9	0	0
Hoops					12	10	0
Marked bars (Staffs.) f.o.t.					12	10	0
Gas strip					12	0	0
Bolts and nuts, ¾ in. × 4 in.					15	5	0
Steel—							
Ship plates	8	2	6	to	8	7	6
Boiler plts.					10	10	0
Chequer plts.					10	5	0
Angles					7	12	6
Tees					8	12	6
Joists					7	12	6
Rounds and squares, 3 in. to 5½ in.					7	15	0
Rounds under 3 in. to ⅜ in. (Untested)					8	0	0
					and upwards		
Flats, over 5 in. wide and up					9	2	6
Flats, 5 in. to 1½ in.					8	2	6
Rails, heavy	8	2	6	to	8	7	6
Fishplates					12	10	0
Hoops (Staffs.)					10	10	0
Black sheets, 24g.					10	2	6
Galv. cor. shts., 24g.					13	0	0
Galv. fencing wire 8g. plain					12	10	0
Billets, soft	£6	0	0	to	6	10	0
Billets, hard					8	2	6
Sheet bars	£5	12	6	to	5	15	0
Tin bars	£5	12	6	to	5	15	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 2½
Sheet to 10 w.g.	1 3
Wire	1 3¾
Rods	1 3
Tubes	1 8½
Castings	1 2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	19.76
No. 2 foundry, Valley	17.25
No. 2 foundry, Birm.	16.00
Basic	18.76
Bessemer	19.26
Malleable	19.26
Grey forge	18.51
Ferro-mang. 80% d/d	100.00
Bess rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	40.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Skelp, sheared steel	1.80
Steel hoops	2.20
Sheets, black, No. 24	2.80
Sheets, galv., No. 24	3.65
Sheets, blue an'l'd., 9 and 10	2.10
Wire nails	2.50
Plain wire	2.40
Barbed wire, galv.	3.20
Tinplate, 100 lb. box	$5.25

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	—
,, furnace	13/6
Other Districts, foundry	—
,, ,, furnace (basis)	12/- to 13/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14	box	18/3
,,	28×20	,,	36/6
,,	20×10	,,	—
,,	18¾×14	,,	—
C.W.	20×14	,,	17/4½
,,	28×20	,,	—
,,	20×10	,,	—
,,	18¾×14	,,	—
Terneplates	28×20	—	per box basis f.o.b.

SWEDISH IRON.

Bars, hammered, £18 10 0	to 19 0 0
Rolled Ord. £15 0 0	to £15 10 0
Nail rods £15 7 6	to £15 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron £5 15 0	to

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½% ..	45%
Water	63¾%	40%
Steam	60%	35%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Jan. 12 ..	61	0	0	dec.	2/6
„ 13 ..	61	11	3	inc.	11/3
„ 16 ..	61	15	0	„	3/9
„ 17 ..	61	12	6	dec.	2/6
„ 18 ..	61	7	6	„	5/-

Electrolytic Copper.

		£	s.	d.		
Jan. 12 ..	66	10	0	No change	
„ 13 ..	66	10	0	„	„
„ 16 ..	66	10	0	„	„
„ 17 ..	66	10	0	„	„
„ 18 ..	66	10	0	„	„

Standard Tin (cash).

		£	s.	d.		
Jan. 12 ..	253	12	6	dec.	12/6
„ 13 ..	250	5	0	„	67/6
„ 16 ..	249	15	0	„	10/-
„ 17 ..	247	0	0	„	55/-
„ 18 ..	246	2	6	„	17/6

Tin (English ingots).

		£	s.	d.		
Jan. 12 ..	252	15	0	dec.	20/-
„ 13 ..	249	5	0	„	70/-
„ 16 ..	248	15	0	„	10/-
„ 17 ..	246	0	0	„	55/-
„ 18 ..	245	0	0	„	20/-

Zinc Sheets (English).

		£	s.	d.		
Jan. 12 ..	35	0	0	No change	
„ 13 ..	35	0	0	„	„
„ 16 ..	35	0	0	„	„
„ 17 ..	35	0	0	„	„
„ 18 ..	35	0	0	„	„

Spelter (ordinary).

		£	s.	d.		
Jan. 12 ..	25	16	3	dec.	3/9
„ 13 ..	25	15	0	„	1/3
„ 16 ..	25	16	3	inc.	1/3
„ 17 ..	25	18	9	„	2/6
„ 18 ..	26	0	0	„	1/3

Lead (English).

		£	s.	d.		
Jan. 12 ..	23	5	0	No change	
„ 13 ..	23	5	0	„	„
„ 16 ..	23	5	0	„	„
„ 17 ..	23	5	0	„	„
„ 18 ..	23	5	0	„	„

Exports of Iron Castings in December and the twelve months 1927, compared with December and the twelve months 1926.

	December, 1926.	December, 1927.	Twelve months, 1926.	Twelve months, 1927.	December, 1926.	December, 1927.	Twelve months, 1926.	Twelve months, 1927.
BUILDERS' CASTINGS— Stoves, Grates, etc., Cisterns, Baths, etc., and cooking and washing boilers:—	Tons.	Tons.	Tons.	Tons.	£	£	£	£
To Argentine Republic	100	137	1,471	1,593	3,641	4,198	58,152	58,519
„ British South Africa	333	316	4,370	3,178	11,109	11,492	147,353	114,697
„ „ East Indies	156	168	1,794	1,828	6,693	8,259	79,041	88,031
„ Australia	70	63	844	916	4,618	4,030	48,940	53,330
„ New Zealand	212	155	2,494	2,056	9,391	9,985	123,018	107,541
„ Other countries	859	818	8,695	8,358	41,604	37,913	425,650	407,526
Total	1,730	1,657	19,668	17,929	77,056	75,877	882,154	829,644
PIPES AND FITTINGS—CAST—								
To Argentine Republic	445	196	8,105	8,947	4,739	2,147	97,685	99,521
„ British South Africa	497	529	7,178	14,427	7,948	7,002	103,088	159,318
„ „ India	245	479	7,420	6,926	4,616	7,499	98,133	105,744
„ Straits Settlements and Malay States	301	2,717	14,548	16,809	3,421	24,971	127,913	163,467
„ Ceylon	19	86	1,836	1,317	313	1,127	21,968	15,580
„ Australia	233	2,565	3,675	11,445	3,718	26,977	53,744	131,961
„ Other Countries	2,742	5,046	44,222	62,952	48,496	62,623	646,227	819,660
Total	4,482	11,618	86,984	122,823	72,711	132,346	1,148,758	1,495,251
HOLLOW-WARE—								
Cast, not Enamelled, and Cast, Tinned	371	451	6,452	4,881	15,283	16,880	230,601	190,864
„ Enamelled	55	82	955	744	5,781	7,244	103,368	76,418
CASTINGS, in the rough—								
Iron	102	107	1,249	1,327	3,772	3,840	39,330	45,741
Steel	15	341	648	1,265	888	12,547	21,967	55,405

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

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18, BENNETTS HILL, BIRMINGHAM.
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FOWLERS BUILDINGS, BOMBAY.
CLIVE STREET, CALCUTTA.
20, SECOND LINE BEACH, MADRAS.
1, HONG KONG ROAD, SHANGHAI.

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JAVA STREET, KUALA LUMPUR.
5, SHAFFRAZ ROAD, RANGOON
NADIR HOUSE, MACLEOD ROAD, KARACHI.
1 SHAREH SONK EL TEWFIKIEH, CAIRO.

PIG IRON

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.,

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE

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19, ST. VINCENT PLACE, GLASGOW.

ZETLAND ROAD, MIDDLESBROUGH.

SMALL ADVERTISEMENTS.

SITUATIONS VACANT AND WANTED.

CHILLED ROLLS, ETC.—Foundry Manager with many years' experience in the manufacture of Chilled Rolls and various Chilled Iron Castings, desires change.—Box 590, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

DIE CASTING.—Executive Engineer, with 10 years' experience of Gravity and Pressure Die Design, capable estimator of die costs and organiser of foundry production for profits, seeks leading position D.O. or Works. —PEARSON, 17, Mostyn Avenue, Wembley Hill, N.W.

PRACTICAL Moulder seeks permanent country situation, anywhere South; thoroughly conversant with cupola and modern methods, capable of sole control; advertiser desires to settle with small country firm at a moderate wage.—Box 586, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

TO FOUNDRY REQUISITE FIRMS.—Foundryman, well known in the Midlands, desires to get in touch with a firm in trade requisites view Traveller, Salesman or Demonstrator; practical and technical knowledge of all branches in foundry practice; age 34 years; replies respectfully treated with strict confidence.—Box 588, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

TECHNICAL AND PRACTICAL FOUNDRYMAN requires position, Manager or Foreman; skilled in moulding machines, sand slinger, plates, loam, green, dry, loam and oil sands, any metals or alloys.—Box 582, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOREMAN seeks position Die-Casting Foundry; 17 years' controlling experience; all types of work; Automobile and Aeroplane work specialist; excellent references. — Box 584, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

AGENCIES.

AGENTS ON COMMISSION, OR DISTRIBUTORS, wanted, all parts, calling on Foundries, for the Sale of "Metallic Phosphoro."—Write CHAS. HALL, 746, Seventh Street, Buffalo, N.Y., U.S.A.

PATENTS AND TRADE MARKS.

THE OWNER of Patent No. 207,773, relating to "Improvements in or relating to Movable Casting Gutters for Centrifugally Casting Metal," is desirous of negotiating with interested parties for the granting of licences thereunder on reasonable terms.—For information apply to MESSRS. LLOYD WISE & Co., Chartered Patent Agents, 10, New Court, Lincoln's Inn, London, W.C.2.

MACHINERY.

MACHINERY PLANT, &c., FOR SALE.

No. 2 CHURCHILL SURFACE GRINDER.

New 4-H.P. HORIZONTAL OIL ENGINES, by Worthington.

Five 36-in. Motor-driven VENTILATING FANS, by Keith Blackman.

BELT-DRIVEN PNEUMATIC POWER HAMMER, 8-in. stroke, 12-in. cylinder.

VERTICAL BOILER, 15 ft. high x 4 ft. 6 in.; reinsure 80 lbs. pressure.

Three "BLAKE" MULTITUBULAR BOILERS, each 12 ft. 6 in. high x 5 ft. diam.; resinsure 150 lbs. pressure.

Ten Second-hand Sets 30-cwt. "Yale" TRIPLEX BLOCKS, about 10 ft. lift.

DOUBLE CYLINDER HORIZONTAL STEAM WINCHES, single and double purchase type, with cylinders 4½ in. to 10 in. diameter; extremely large variety.

CATALOGUE (10,000 Lots) ON APPLICATION.

THOS. W. WARD LTD.,
ALBION WORKS, SHEFFIELD.

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WANTED, Two-ton to 50-cwt. Cupola; Whiting type preferred; complete with fan, etc.—Box 578, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY TESTING MACHINE FOR SALE; 4 tons tensile, 2 tons transverse; in first-class condition. Also complete line of Amsler Testing Machines.—T. C. HOWDEN & Co., 5 & 7, Fleet Street, Birmingham.

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30-CWT. CUPOLA, excellent condition, 2 ft. 6 in. outside dia.; makers, Constructional Engineering Company, Birmingham.

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MUMFORD POWER SQUEEZING MOULDING MACHINE, to take 20 in. x 14 in. Boxes; good condition.

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'Phone: 287 SLOUGH.

CRANE LADLES

½ TON (NEW), enclosed gear ..	£12
1 TON (NEW), enclosed gear ..	£20
3 TON EVANS, as new	£30
5 TON EVANS, as new	£36
8 TON EVANS, good	£40
10 TON STEVENSON, equal to new	£45
12 TON EVANS, equal to new ..	£65

All have Worm and Bevel Gear.

LARGEST STOCK OF FOUNDRY PLANT IN ENGLAND. PLEASE SEND FOR LISTS.

BUY FROM ME AND SAVE MONEY.

ALEX. HAMMOND, *Foundry Machinery Merchant,*
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IMPORTANT SIX DAYS' SALE OF THE ENTIRE CONTENTS OF THE GLOBE IRON WORKS OF JOHN MUSGRAVE & SONS, LTD., BOLTON, LANCS.

MESSRS. FULLER, HORSEY, SONS & CASSELL will Sell by Auction, in Lots, on the Premises, on TUESDAY, JANUARY 31, 1928, and following days, at 11 o'clock precisely each day,

HIGH-CLASS MACHINE TOOLS,

including 70 Screw-cutting and other Lathes, 10 Combination and other Turret and Capstan Lathes, by Herbert, Brown & Sharpe, etc., Potter & Johnston & Cleveland Automatics, 24 Horizontal and Vertical Milling Machines, by Brown & Sharpe, Le Blond, Kendall & Gent, Becker and others, 4 Plano-type ditto, 9 Planing Machines up to 30 ft. x 10 ft. x 10 ft., 6 Side-Planers up to 13 ft. x 9 ft. 6 in., 7 Universal, Plain and Surface Grinders, by Brown & Sharpe, Norton, Churchill, etc., Disc and Tool and Cutter Grinders, various, 10 Pearn-Richards No. 4 and other Horizontal Boring Machines, 9 Duplex and other Vertical Boring and Turning Mills, by Bullard, Richards, etc., 25 Radial, Pillar and Sensitive Drilling Machines, Noble & Lund 48-in. Band Saw, Haigh 7 ft. Broaching Machine, Richards' Key Seater, Power Hack Saws.

FOUNDRY PLANT,

including Six Cupolas, Two Bonvillain Hydraulic Moulding Machines, 8 ft. Loam Mill, Four Loam Mixers, Wright Tilting Furnace, Foundry Boxes, Ladles, etc.

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WOOD-WORKING MACHINERY,

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A 20-ton Wagon Weighbridge, 12 Avery Weighing Machines (5 cwt. to 3 tons), Musgrave 2-stage Air Compressor, Broom & Wade 2-cylinder Compressor, Air Receivers, Massey 1-cwt. Pneumatic Hammer, 100-ton Hydraulic Mandrel Press, Dorman Die-Casting Machine Two Monometer Metal Furnaces, Avery 30-ton Universal Testing Machine, Izod Impact Tester, Newall 4-ft. Measuring Machine, Air Pump and Pipe Testing Plant, Bar Stretching, Bending and Straightening Presses, Laboratory Apparatus, Gas Furnaces, Heating Plant, Tanks up to 37 ft. by 32 ft. by 3 ft., Pumps, Fans and Blowers, Cylinder Boring Engines and Bars, Marking-off Tables, Hydraulic Jacks, Engineers' Small Tools, Shafting, Belting, Winches, Baulk Timber, etc.

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